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Stennis Space Center, MS 39529-5004

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Inverted Echo Sounder Observations During the Kuroshio Extension Regional Experiment

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Sea surface height anomalies measured by inverted echo sounders with pressure gauges (IES/PGs) were made in the vicinity of the Kuroshio Extension, near 35° N, 143° E, as part of the Kuroshio Extension Regional Experiment (KERE). These instruments provide information concerning the height of the sea surface as well as information concerning movement of mesoscale features in the KERE area. The moorings were deployed from July 1992 through June 1994. This report describes the IES/PG data and supporting ship XBT measurements.

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INVERTED ECHO SOUNDER OBSERVATIONS DURING THE KUROSHIO EXTENSION REGIONAL EXPERIMENT

Introduction

A major component of the field activities for the Kuroshio Extension Regional Experiment (KERE) is focused on collecting and analyzing data from inverted echo sounders with pressure gauges (IES/PGs). In this report the collection, processing and preliminary analysis of the IES/PG data and the associated XBT data are described, and various plots are presented. These data are generally of good quality and constitute a significant contribution to the understanding of Kuroshio dynamics.

The initial cruise was in July, 1992. Five current meter moorings (CMMs) and 10 IESs were deployed, and 18 conductivity-temperature-depth (CTD)/hydrographic stations were conducted. Forty expendable bathythermographs (XBTs) were dropped at IES sites for calibration purposes. Except for 4 IESs, all moorings and CTD stations lay along a TOPEX/POSEIDON groundtrack. The hydrographic observations included water samples which were analyzed for salinity, dissolved oxygen, silica, nitrate, and phosphate. These hydrographic and XBT observations are discussed by Teague et al. (1993). The CMMs and IESs were recovered in July 1993 and subsequently redeployed, with the exceptions of CMM A and IESs 9 and 10 which were not recovered. In addition, IES 7 and 8 were not redeployed. With IES redeployment, 26 calibrations XBTs were taken.

The four CMMs and the IESs (except for IES 6) were finally recovered in May 1994. There were 12 additional calibration XBTs at the IES sites. All of the IES data and the 1993 and 1994 calibration XBTs are discussed here. The CMMs are discussed in Hallock and Teague (1995).

Background

The ability to monitor and describe fluctuations in oceanic mesoscale features such as the Kuroshio and associated rings and eddies is essential for understanding the evolution of such features. Traditionally, this has been done by hydrographic surveys which are limited to relatively short time intervals, and current meter moorings which are expensive and exclude the upper layers of the ocean in high-energy regions. More recently, satellite infrared imagery has provided series of synoptic pictures of sea-surface temperature where major mesoscale features can often be seen in great detail. The last technique sees only the surface signature, however, experience has shown that sea-surface temperature often provides a distorted picture of dynamically significant features and, in some cases, fails to see them at all.

A technique for obtaining time-series of changes in first-mode baroclinic features has evolved which uses the IES. The IES is a bottom-moored, upward-looking echo sounder, which records time-series of round-trip acoustic travel time (TT) to the sea surface. The entire mooring configuration is compact, weighing about 250 lb in air and extending 2 m above the bottom. Changes in the thermal structure of the intervening water column (i.e. raising or lowering of the thermocline) and, to a lesser extent, changes in sea-surface height, result in changes in TT. Changes in the depth of the thermocline are indicative of movement of mesoscale ocean features such as eddies or currents. This method of acoustically monitoring the depth of the thermocline was first proposed by H. T. Rossby (1969). The first scientific use of the IES was reported by Watts and

Rossby (1977).

The IES is moored with an expendable anchor which is jetisoned by an acoustically operated release mechanism. In principle, IES deployment and recovery procedures are similar to those used for current-meter moorings. The latter, however, are usually much larger than an IES and thus fewer current-meter mooring deployments (e.g. 1 - 5) than IES deployment are feasible for a given cruise. Consequently, many IESs can be deployed or recovered on a single cruise (up to about 25) since deployment requires only about one hour and recovery about three hours. Deployment and recovery procedures are discussed by Teague and Hallock (1987). The analysis and interpretation of IES observations are discussed elsewhere (Hallock, 1987; Teague and Hallock, 1990; Hallock et al., 1989; 1991; 1993).

Instrument Description

The Sea Data Corporation (SDC) Model 1665 IES weighs about 150 lb in air; the anchor adds about 100 lb. The IES electronics package is housed in a 17" diameter glass sphere near the top of the fiberglass shroud. Additional flotation (a 13" sphere) is located in the lower part. The anchor line (1/4" nylon braid) is shackled to several links of stainless steel chain which is, in turn, secured to a hinged pin in an assembly, known as a "release block", on the bottom of the shroud. There are electrical connections through the large sphere to the release block and to the transducer, located on the top of the shroud. When deployed the IES floats about 1 m above the bottom with its transducer pointed upward. Tethered to the protective bale around the transducer, a 10" glass sphere floats about 10 m above the IES. The 10" sphere contains a radio beacon and strobe which are activated whenever the sphere is rotated from its deployed position. During normal operation, the IES/PG samples pressure, temperature, ambient noise and a burst of up to 24 travel times over a period of several minutes during each sampling interval (e.g. 1 hour).

The Model 1665 IES uses the Paroscientific 10000 psi DIGIQUARTZ quartz pressure sensor for extreme pressure accuracy and resolution. The pressure channel measures with a resolution of about 1:1,000,000 (0.01 psi or about 0.6 mb). Ambient noise is measured through a single WOTAN (Weather Observation Through Ambient Noise) channel at 10 kHz. Temperature is measured with a 0.1 °C interchangeable thermistor which has an overall accuracy of 0.15 °C and a resolution of about 0.0007 °C.

IES Data Processing

IES data are internally recorded on cassette tapes. These tapes are normally removed from the instrument at sea. At NRL, data are transferred in hexidecimal format from the tapes to disk files on a Sun Work Station in conjunction with a SDC Asynchronous Reader Interface (ARI) connected to a SDC Model 12B Reader. Engineering data, recorded every four hours, are then separated from the IES data record. Engineering data include system voltages, currents, and other information useful for tracking the performance of the IES. The ASCII encoded hexidecimal data are decoded and stored in unedited disk files. Each sample in the raw, unedited file consists of 28 variables: time, pressure, temperature, ambient noise, and 24 travel times. Appropriate calibrations are applied and the results written to another file consisting of five variables for each sample: time, pressure, temperature, ambient noise, and a single travel time. The single travel times were computed using the mode of the Rayleigh distribution (Watts and Rossby, 1977).

Calibration and utility of the ambient noise measurements are uncertain at this time. No further reference is made to the ambient noise measurements in this report.

Pressure and temperature data were relatively clean and were despiked using a first difference test. Seven primary tidal constituents (O1, K1, Q1, P1, M2, K2, N2, and S2) were then subtracted from the pressure series. Resulting detided pressure data were then plotted and any remaining pressure spikes were manually removed from the original pressure series. Amplitudes and phases of each tidal constituent provided a cross check on the absolute time attached to each record. To determine the long term sensor drift, an exponential function was fitted to the low-pass filtered pressure series. The resulting exponential trend was subtracted from the unfiltered series.

Some specific problems with the IES/PG data are now described. Long term pressure trends appear to remain in some of the pressure records in addition to pressure sensor adjustment problems near the beginning of the pressure records. Temperatures were noisy for IES2 (1992–1993) and also required a +4.8° offset. No pressures and temperatures were recorded for IES8 (1992–1993) and IES4 (1993–1994). However, this problem was isolated to one instrument (serial no. 017) which was deployed at site 8 in 1992 and then redeployed at site 4 in 1993. In addition, clock problems resulted in a 5 day gap in the data between day 221 and 226 at IES7 (1992–1993).

Tables provided in this report include IES deployment summaries (Table 1), IES statistics (Table 2), and XBT positions (Tables 3 and 4). A picture of an IES appears after the tables, followed by location plots for the data, and then time series plots of IES travel times (TT), unfiltered IES pressure records, low-pass filtered (40-hour cutoff frequency) IES pressure records, and IES temperatures. XBT profiles are shown after the IES plots. IES plots are labeled by year and IES number at the top of each plot. For example, 92IES1 denotes 1992 and IES1. XBT plots are indentified by the XBT numbers which are given in Tables 3 and 4.

Acknowledgments

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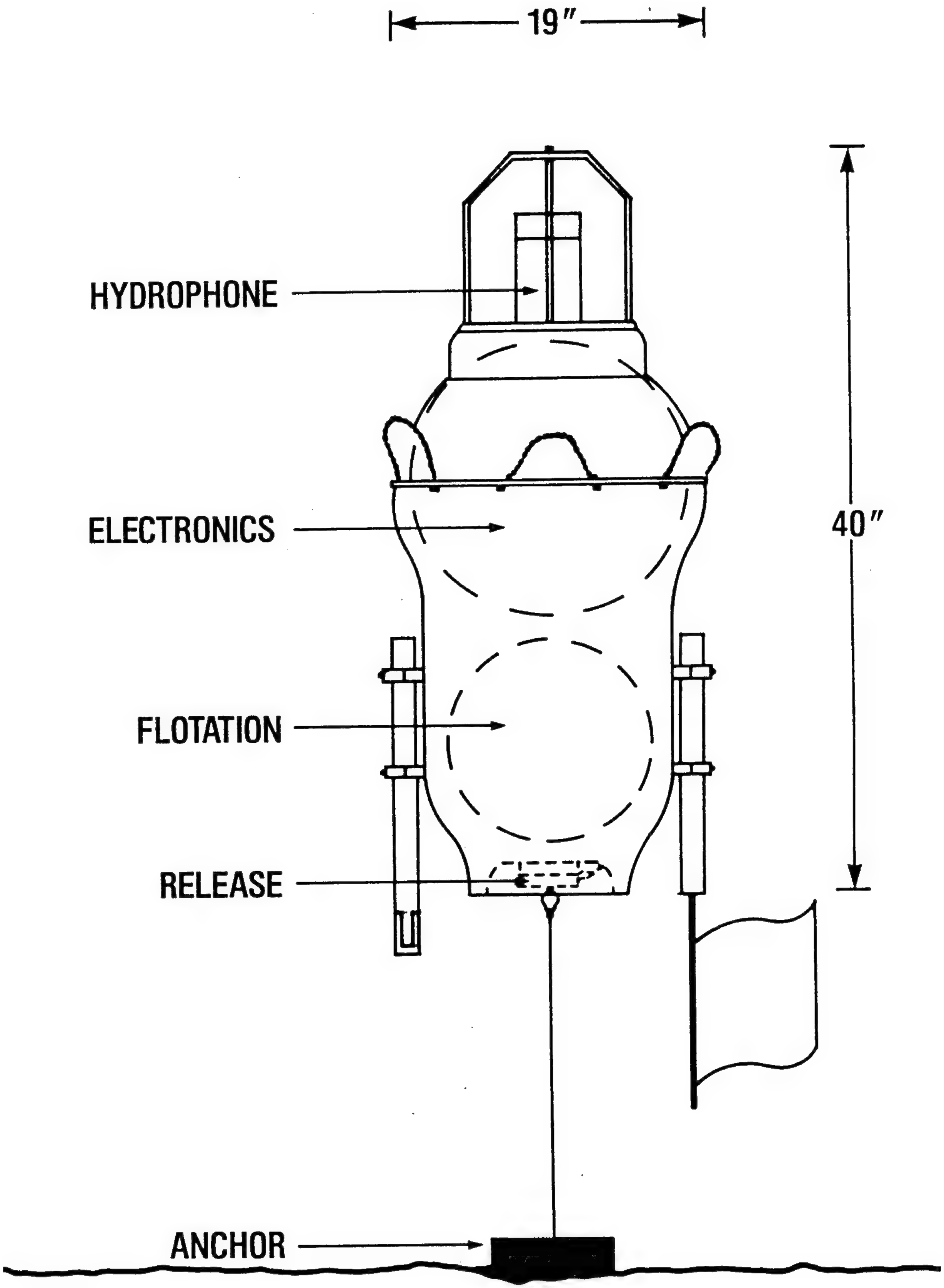
Table 1: IES SUMMARY						
IES	Start Day	End Day	Lat ° N	Lon ° E	Bottom Pres	Parameters
92IES1	192.42	538.75	36.57	142.07	2650.	p,t,tt
92IES2	195.34	539.71	36.20	142.30	3682.	p,t,tt
92IES3	197.38	540.92	35.72	142.60	4378.	p,t,tt
92IES4	198.17	542.75	35.27	142.87	5663.	p,t,tt
92IES5	198.46	543.59	34.75	143.18	5479.	p,t,tt
92IES6	200.17	544.25	34.27	143.47	5762.	p,t,tt
92IES7	203.00	539.50	36.51	142.76	5818.	p,t,tt
92IES8	202.59	541.54	35.73	143.28	6200.	tt
93IES1	181.59	510.29	36.57	142.07	2644.	p,t,tt
93IES2	180.84	510.50	36.20	142.30	3609.	p,t,tt
93IES3	180.63	509.46	35.72	142.60	4402.	p,t,tt
93IES4	180.42	509.29	35.27	142.87	6000.	tt
93IES5	180.25	508.54	34.75	143.18	5483.	p,t,tt

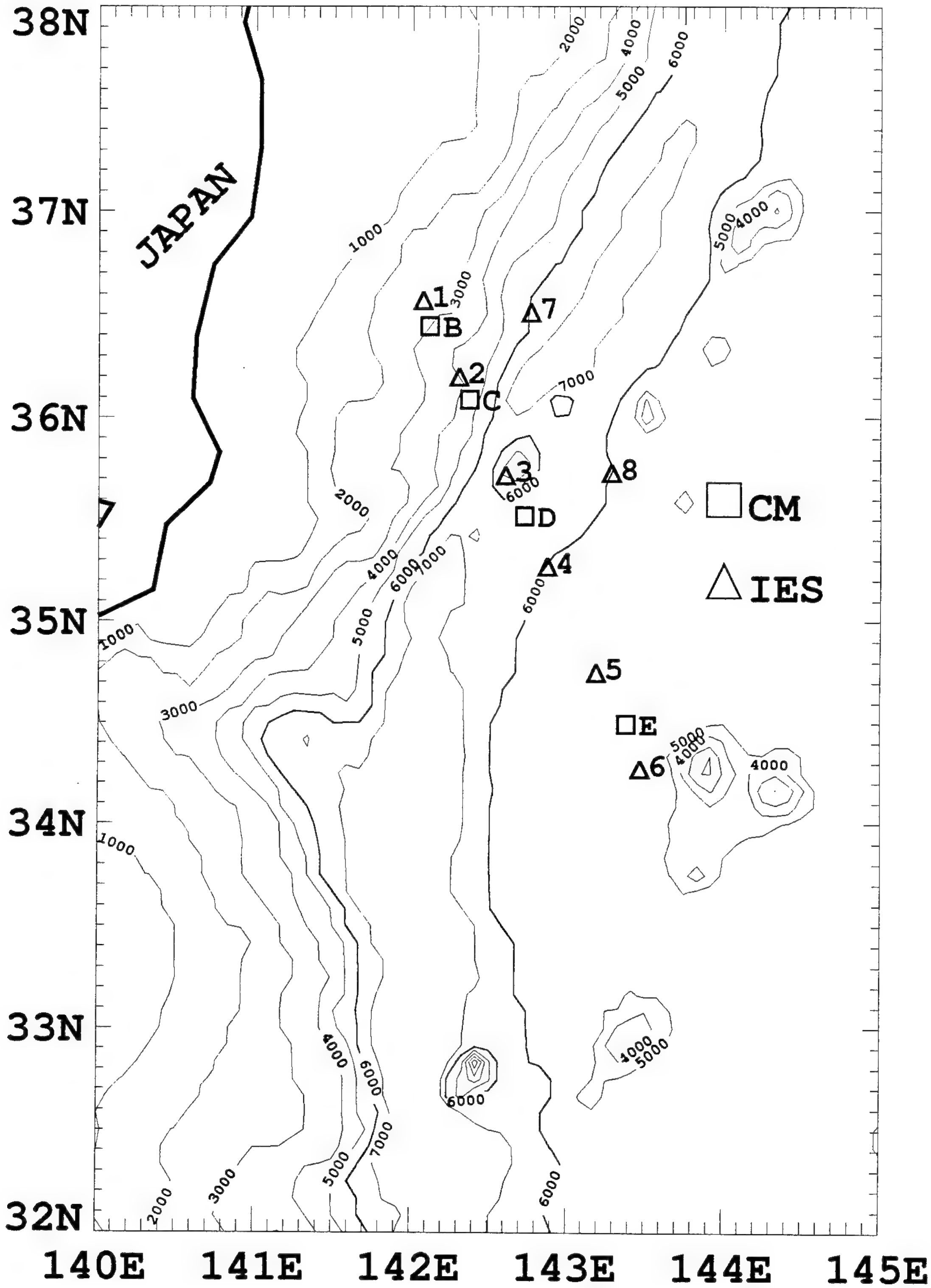
Table 2: IES STATISTICS								
Meter ID	TT_{min}	$TTmax$	$\overline{TT}$	σ_{TT}	$\overline{T}$	σ_T	$\overline{P}$	σ_P
92IES1	0.313	0.330	0.322	0.282E-02	1.6	0.05	2650	0.3
92IES2	0.262	0.289	0.275	0.425E-02	1.4	0.3	3682	0.4
92IES3	0.139	0.175	0.153	0.782E-02	1.5	0.03	4378	0.3
92IES4	0.405E-01	0.722E-01	0.518E-01	0.695E-02	1.7	0.02	5663	0.4
92IES5	0.321	0.347	0.329	0.389E-02	1.6	0.03	5479	0.3
92IES6	0.278	0.295	0.285	0.237E-02	1.7	0.03	5762	0.6
92IES7	0.166	0.189	0.177	0.326E-02	1.5	0.00	5818	0.3
92IES8	0.129E-01	0.462E-01	0.284E-01	0.816E-02				
93IES1	0.311	0.328	0.316	0.293E-02	1.7	0.05	2644	0.4
93IES2	0.202	0.223	0.211	0.353E-02	1.5	0.03	3609	0.3
93IES3	0.167	0.194	0.181	0.498E-02	1.5	0.03	4402	0.3
93IES4	0.350	0.383	0.362	0.568E-02				
93IES5	0.330	0.357	0.338	0.466E-02	1.6	0.03	5483	0.4

Table 3: XBT SUMMARY (1993)						
Cast	Day	Lat	Lon	Zmin (m)	Zmax (m)	IES Site
182	172.80	36.57	142.07	1.	750.	1
183	172.81	36.57	142.06	1.	750.	1
185	173.52	36.51	142.75	1.	750.	7
186	173.53	36.51	142.75	1.	750.	7
187	173.80	36.20	142.30	1.	750.	2
188	173.80	36.20	142.30	1.	750.	2
189	174.91	35.72	142.60	1.	750.	3
190	174.92	35.72	142.60	1.	750.	3
191	175.66	35.73	143.29	1.	750.	8
192	175.67	35.72	143.30	1.	750.	8
194	176.85	35.27	142.87	1.	750.	4
195	176.86	35.27	142.87	1.	750.	4
196	177.64	34.75	143.20	1.	750.	5
197	177.66	34.75	143.18	1.	750.	5
198	178.32	34.27	143.47	1.	750.	6
201	178.33	34.27	143.46	1.	750.	6
202	180.18	34.75	143.19	1.	750.	5
203	180.18	34.75	143.18	1.	750.	5
204	180.40	34.27	142.87	1.	750.	4
205	180.41	34.27	142.88	1.	750.	4
206	180.57	35.72	142.60	1.	750.	3
207	180.58	35.72	142.60	1.	750.	3
208	180.76	36.20	142.30	1.	750.	2
209	180.77	36.20	142.30	1.	750.	2
210	181.49	36.57	142.07	1.	750.	1
211	181.50	36.57	142.07	1.	750.	1

Table 4: XBT SUMMARY (1994)						
Cast	Day	Lat	Lon	Zmin (m)	Zmax (m)	IES Site
1	143.74	34.75	143.19	1.	750.	5
2	143.75	34.75	143.20	1.	750.	5
3	144.37	35.26	142.88	1.	750.	4
4	144.38	35.27	142.88	1.	750.	4
5	144.62	35.72	142.60	1.	750.	3
6	144.64	35.72	142.60	1.	750.	3
7	145.48	36.57	142.07	1.	750.	1
8	145.49	36.57	142.07	1.	750.	1
9	145.49	36.57	142.07	1.	750.	1
10	145.63	36.20	142.30	1.	750.	2
11	145.64	36.20	142.30	1.	750.	2
12	145.64	36.20	142.30	1.	750.	2



Sea Data Model 1665 Inverted Echo Sounder.



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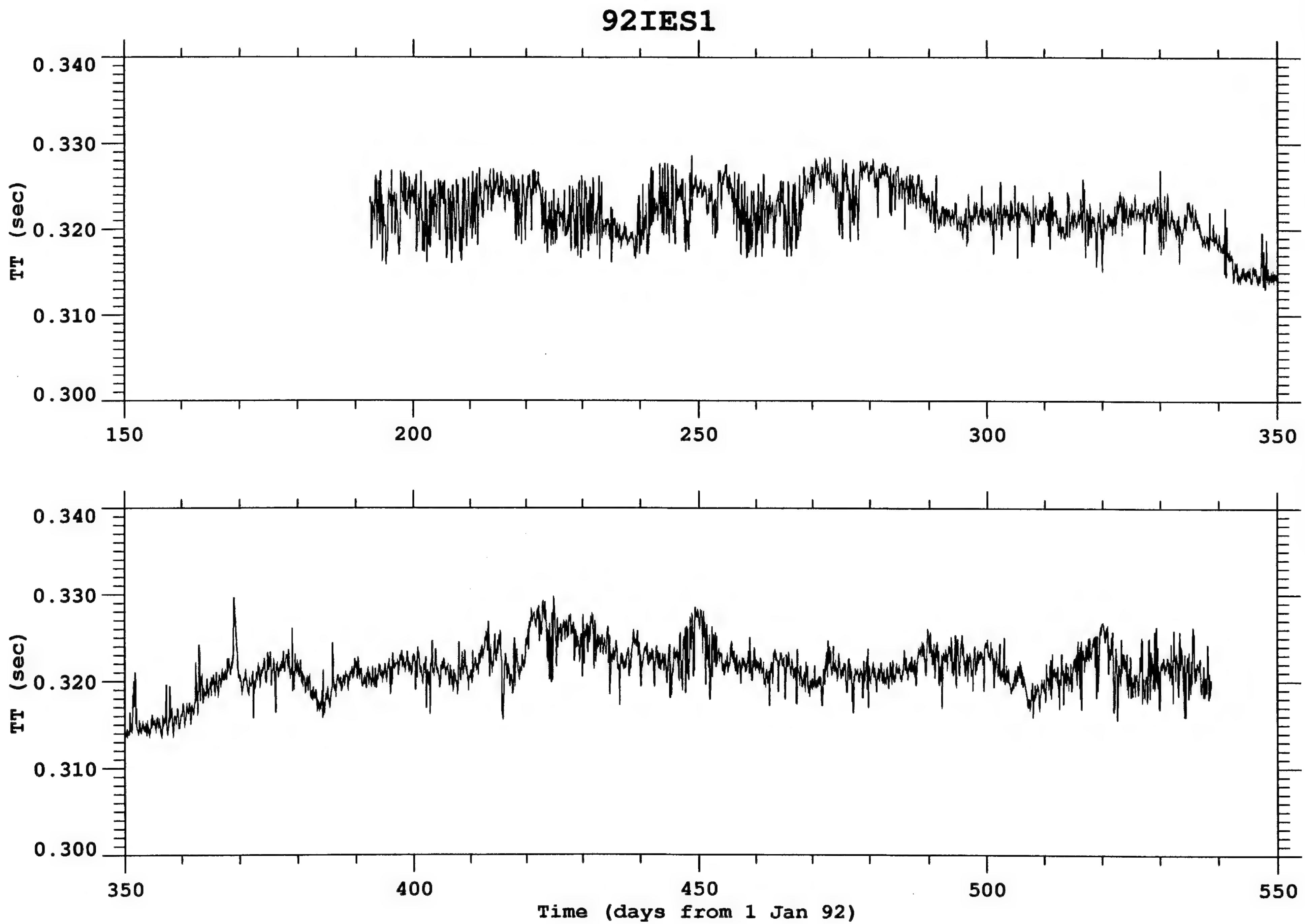

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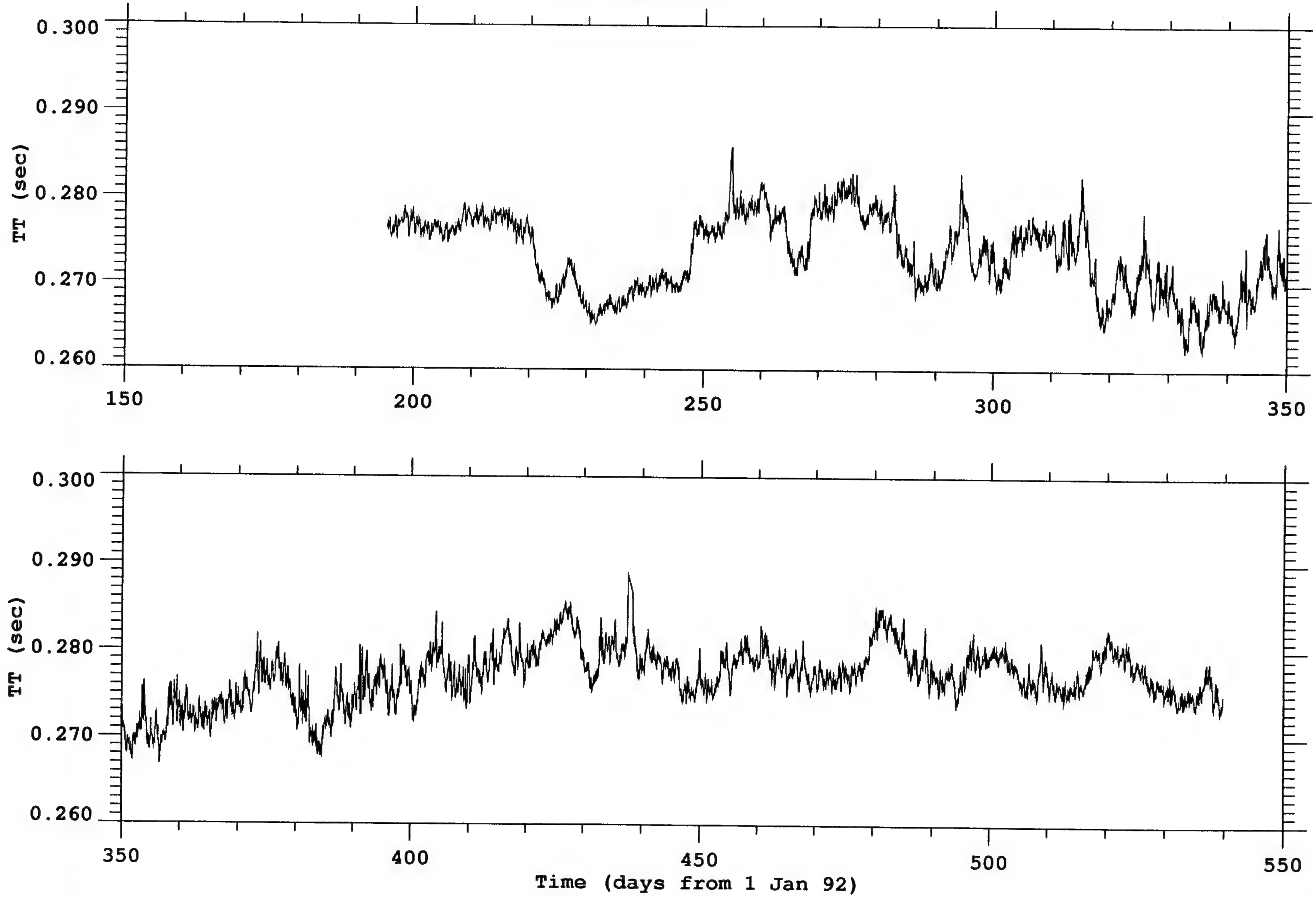

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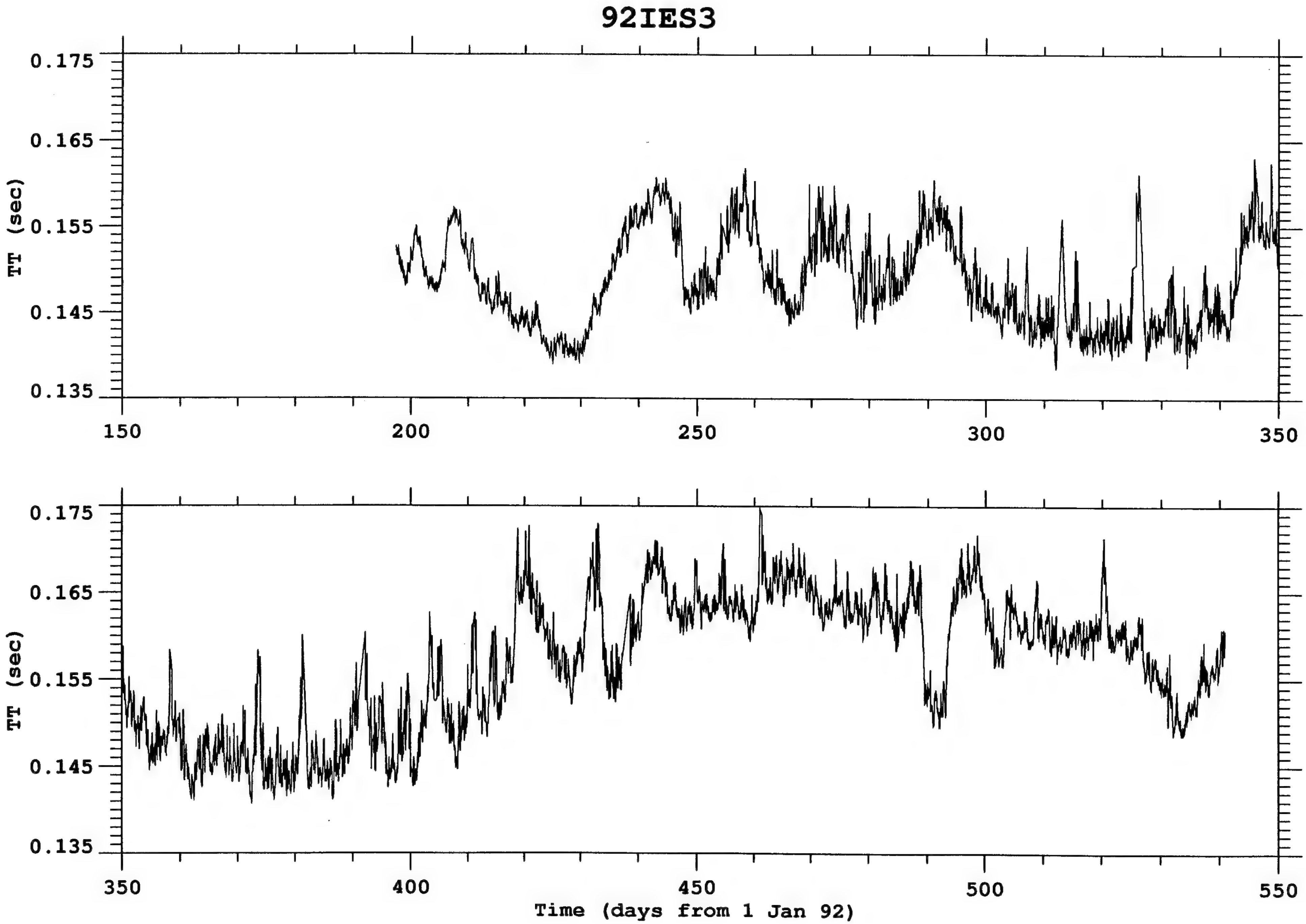
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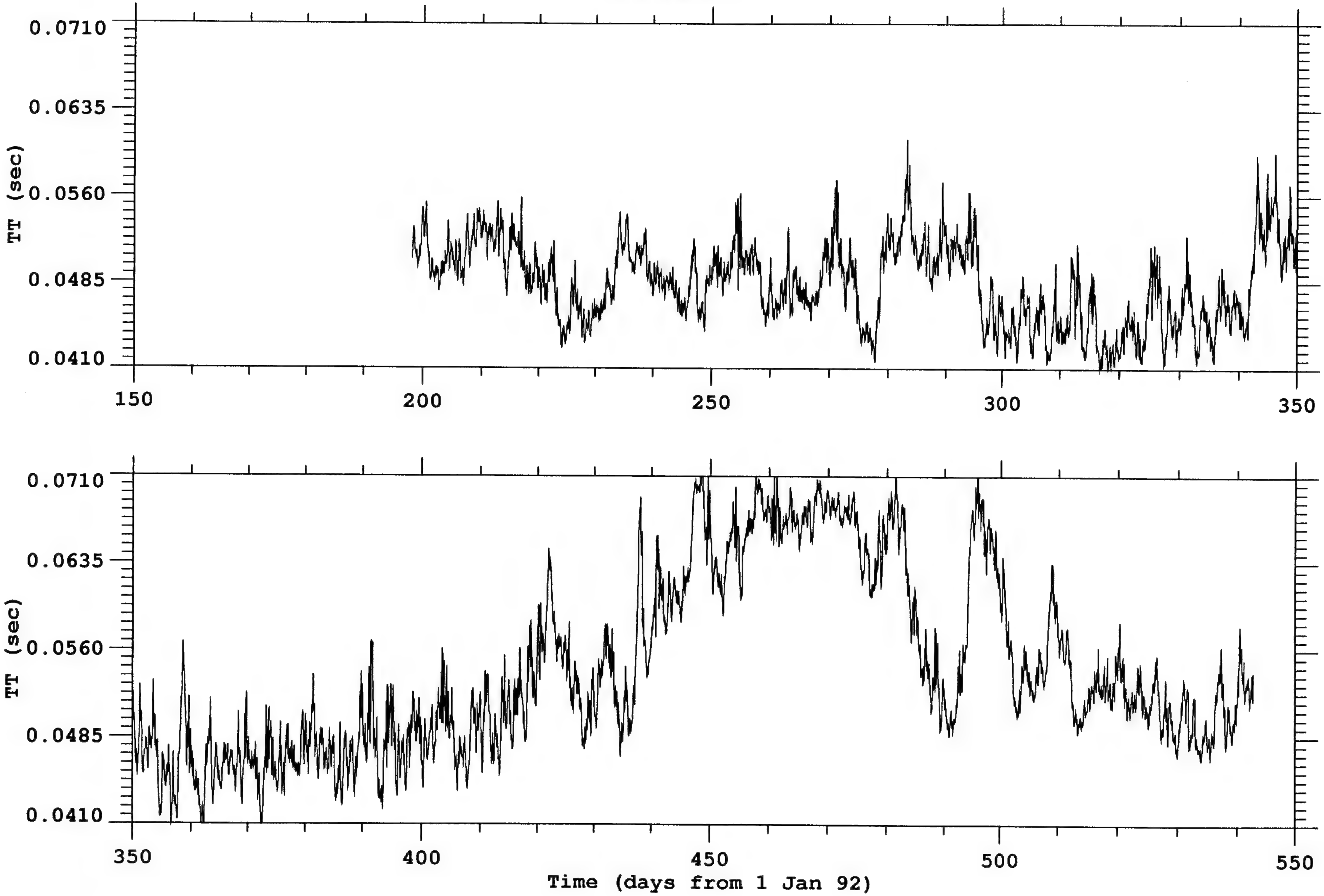

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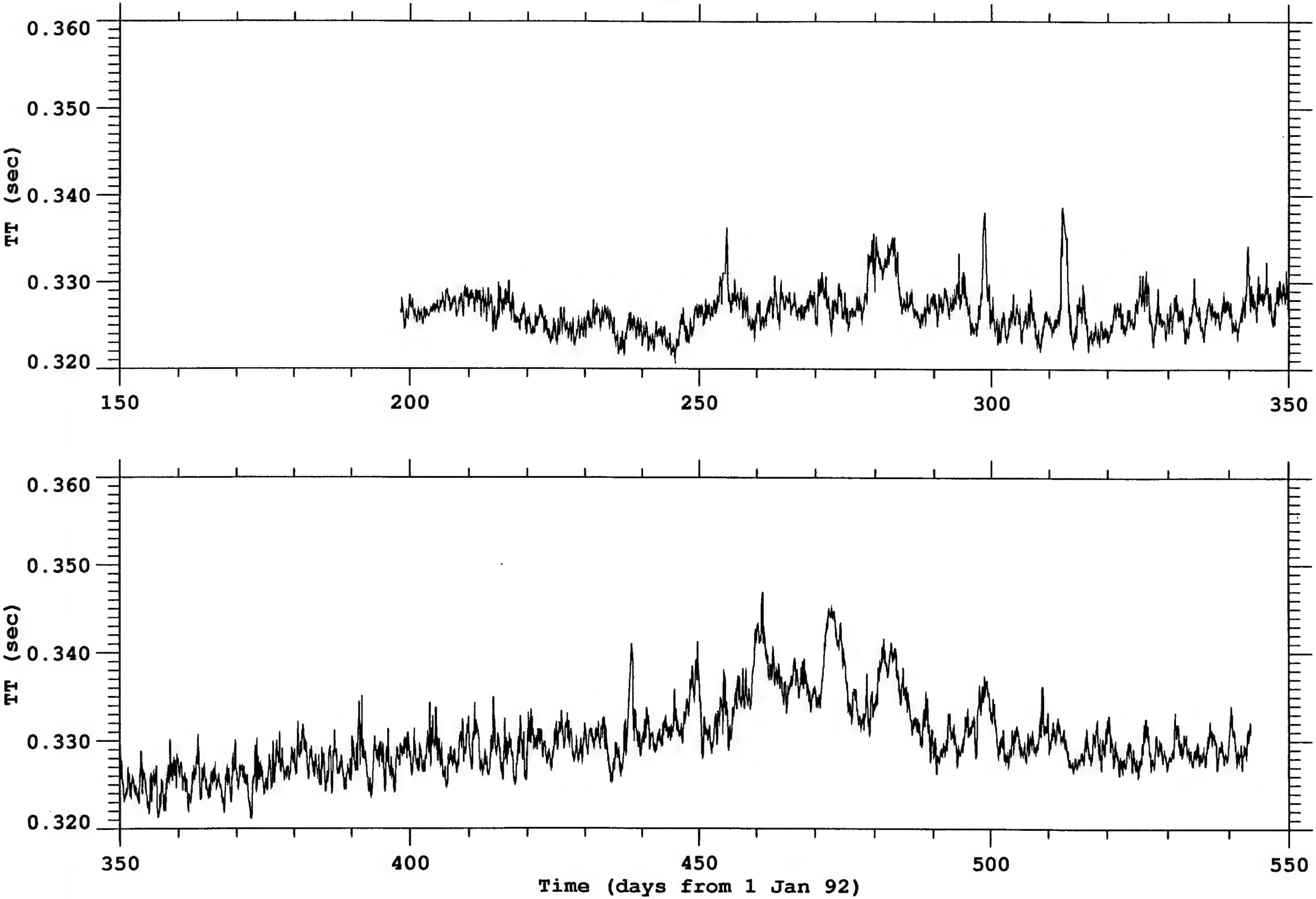

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Time (days from 1 Jan 92)

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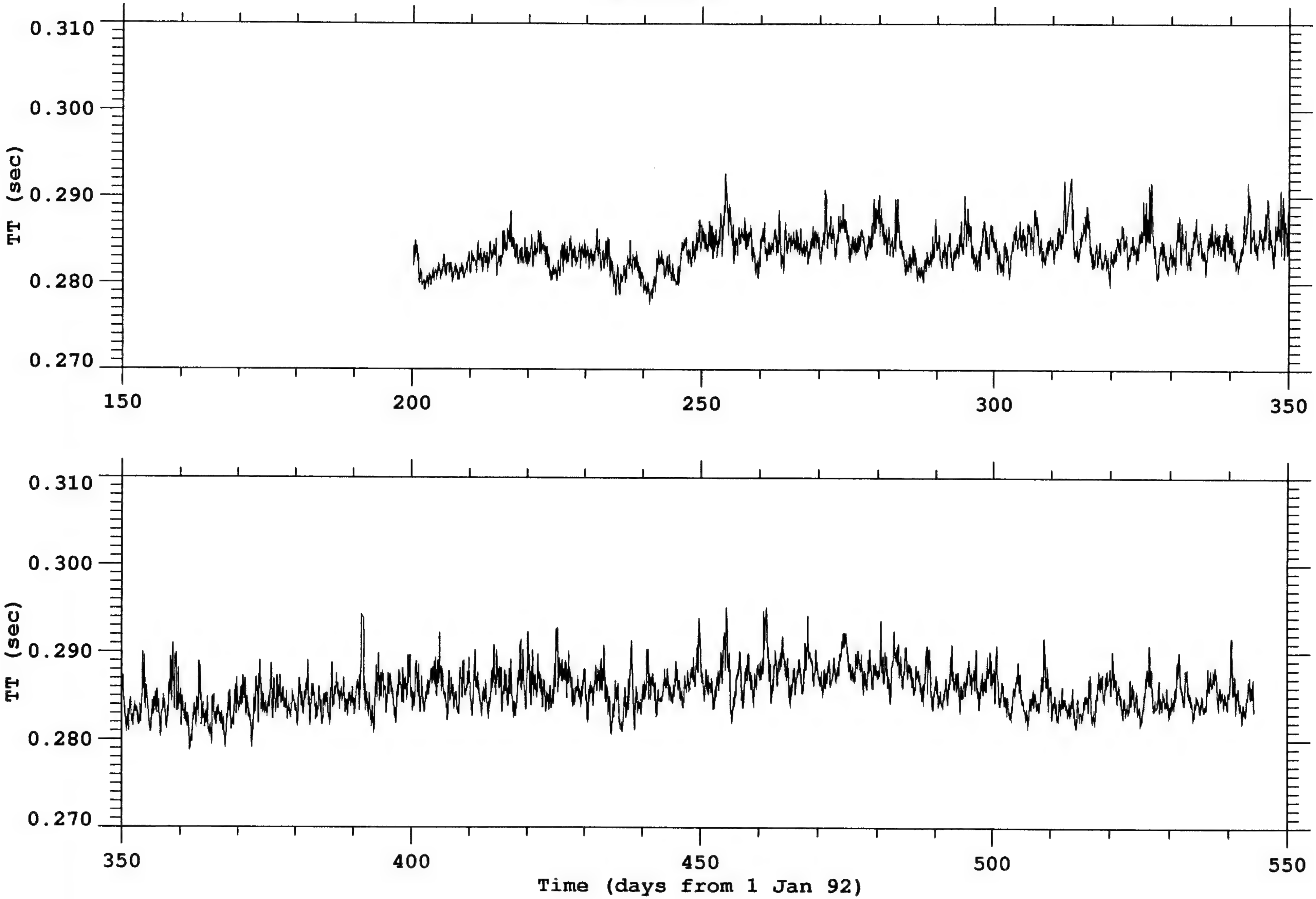

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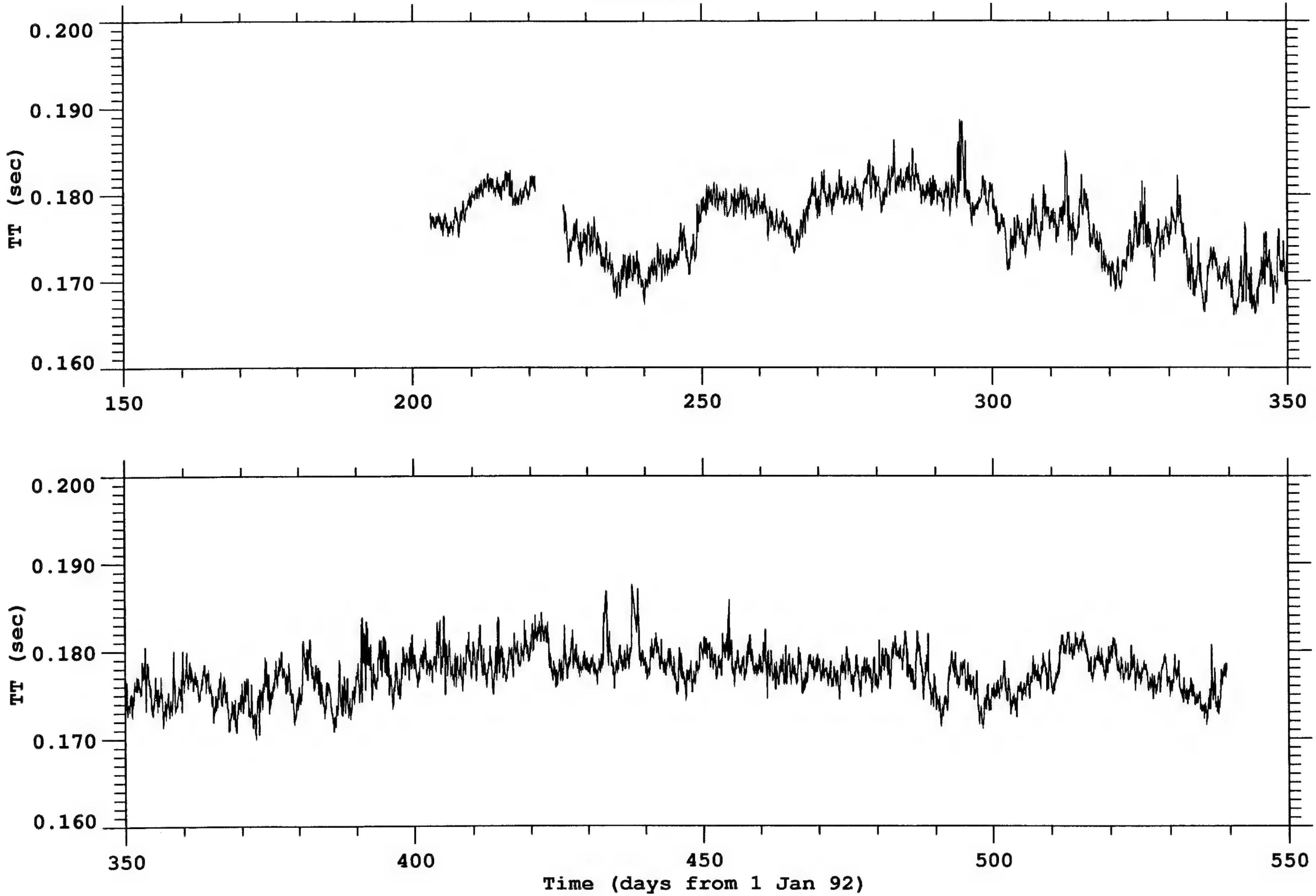

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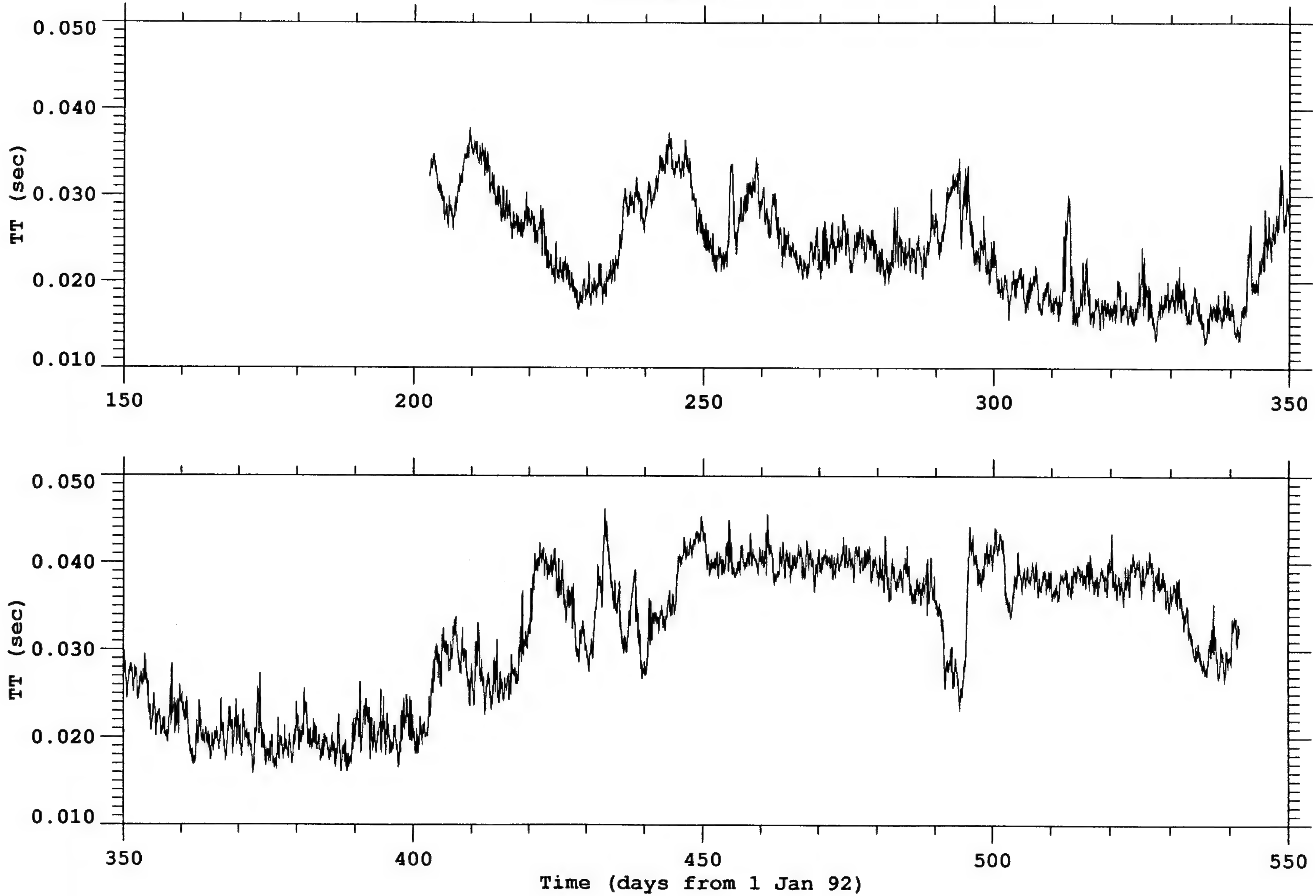

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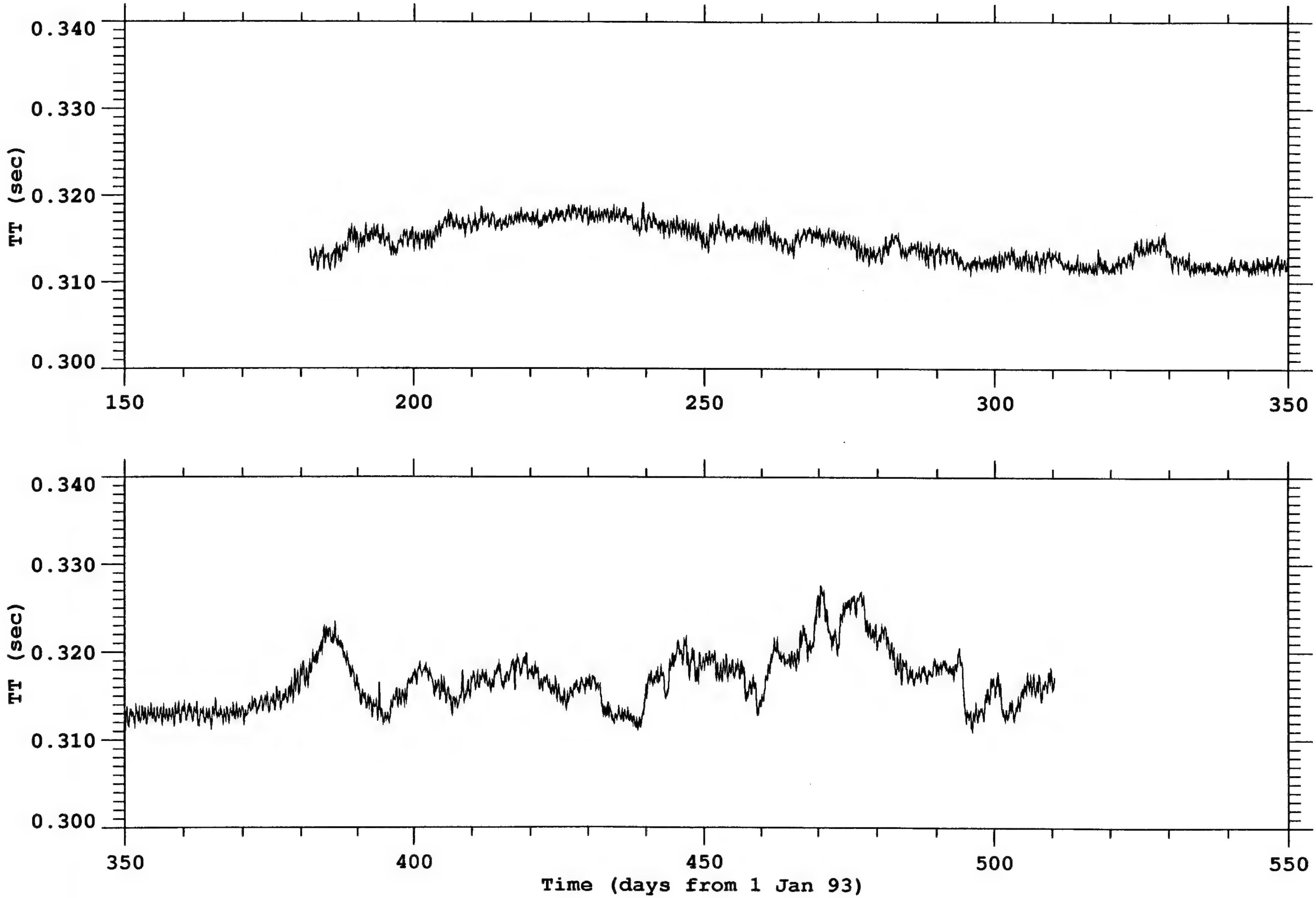
93IES1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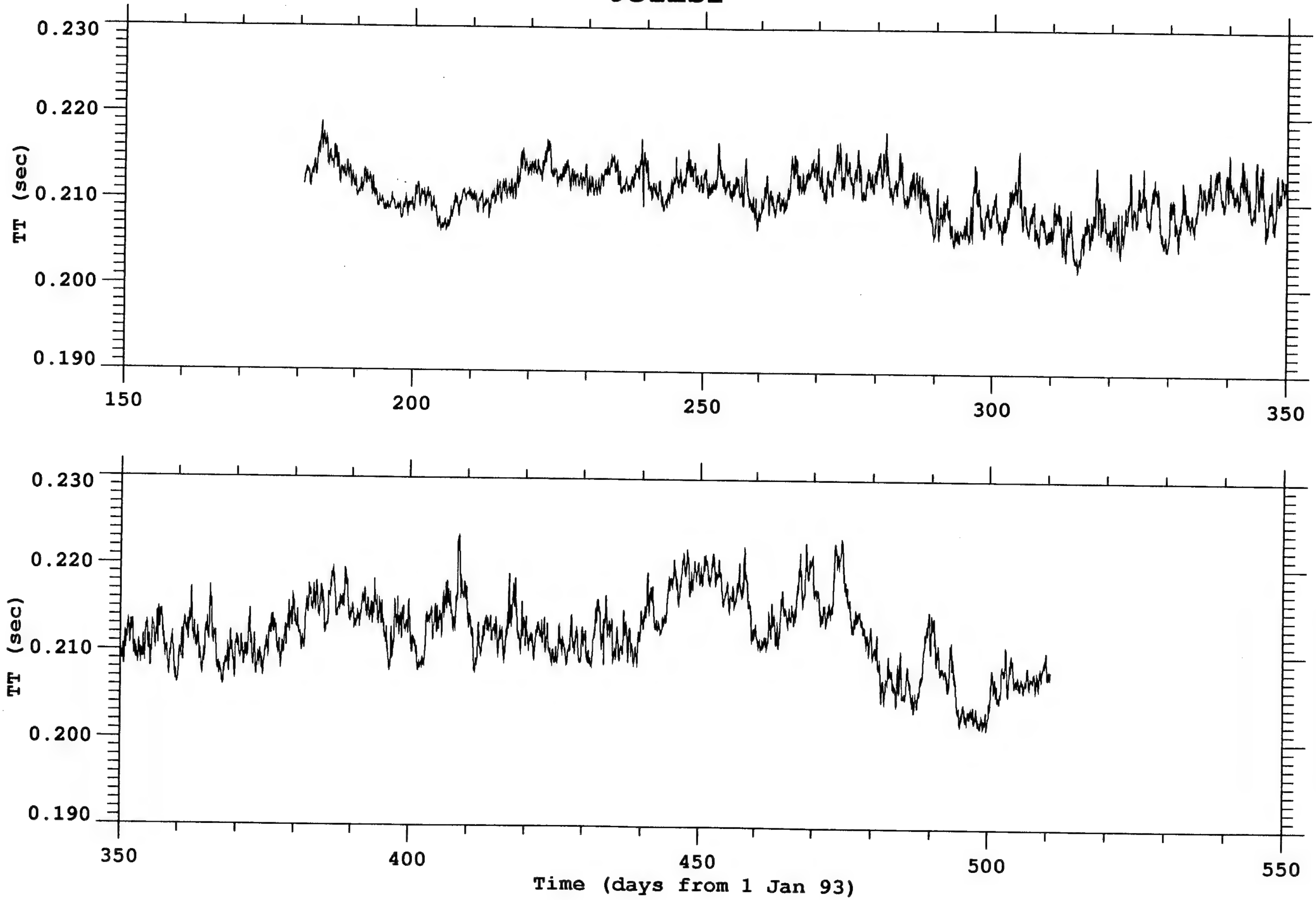
93IES2



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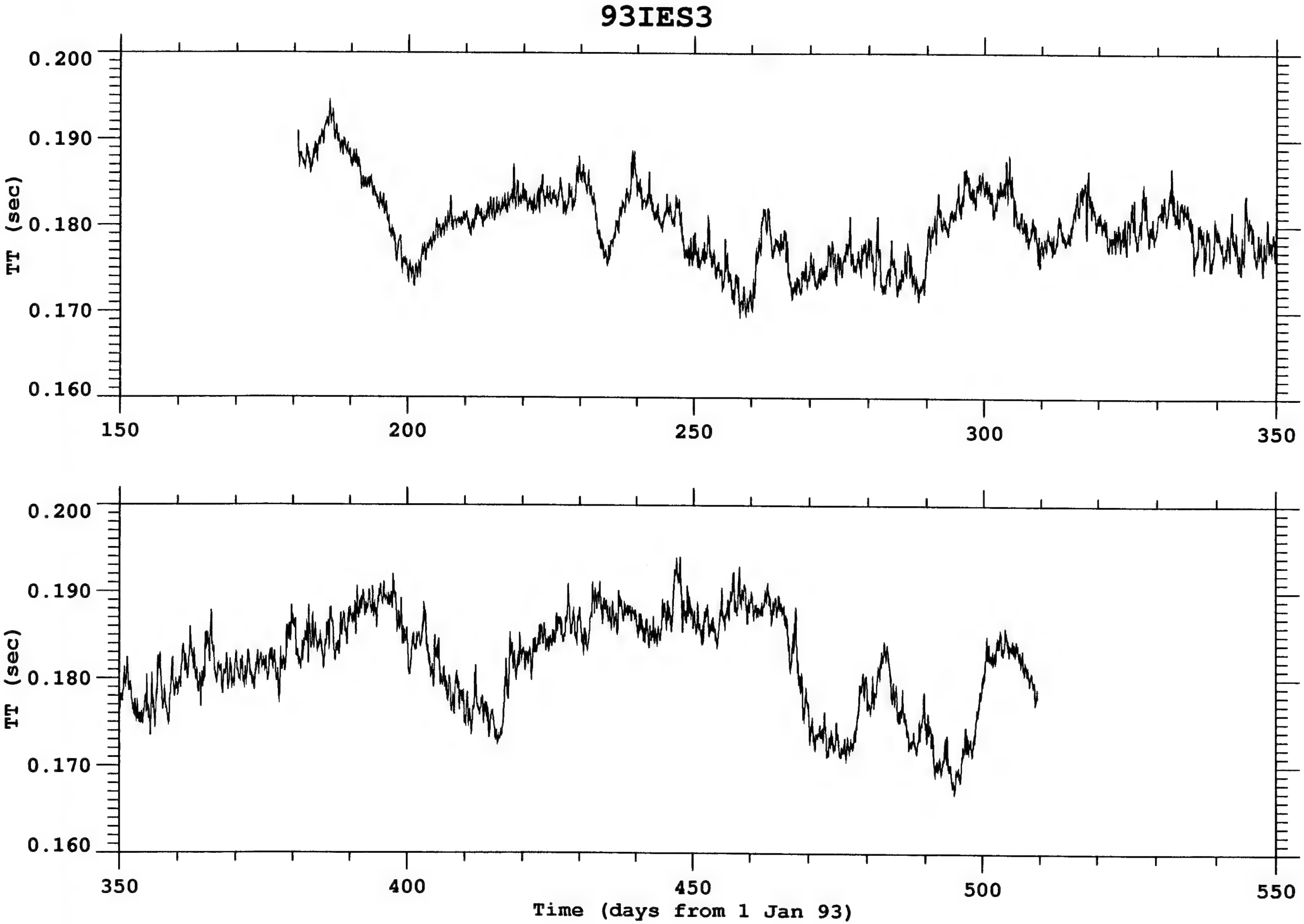
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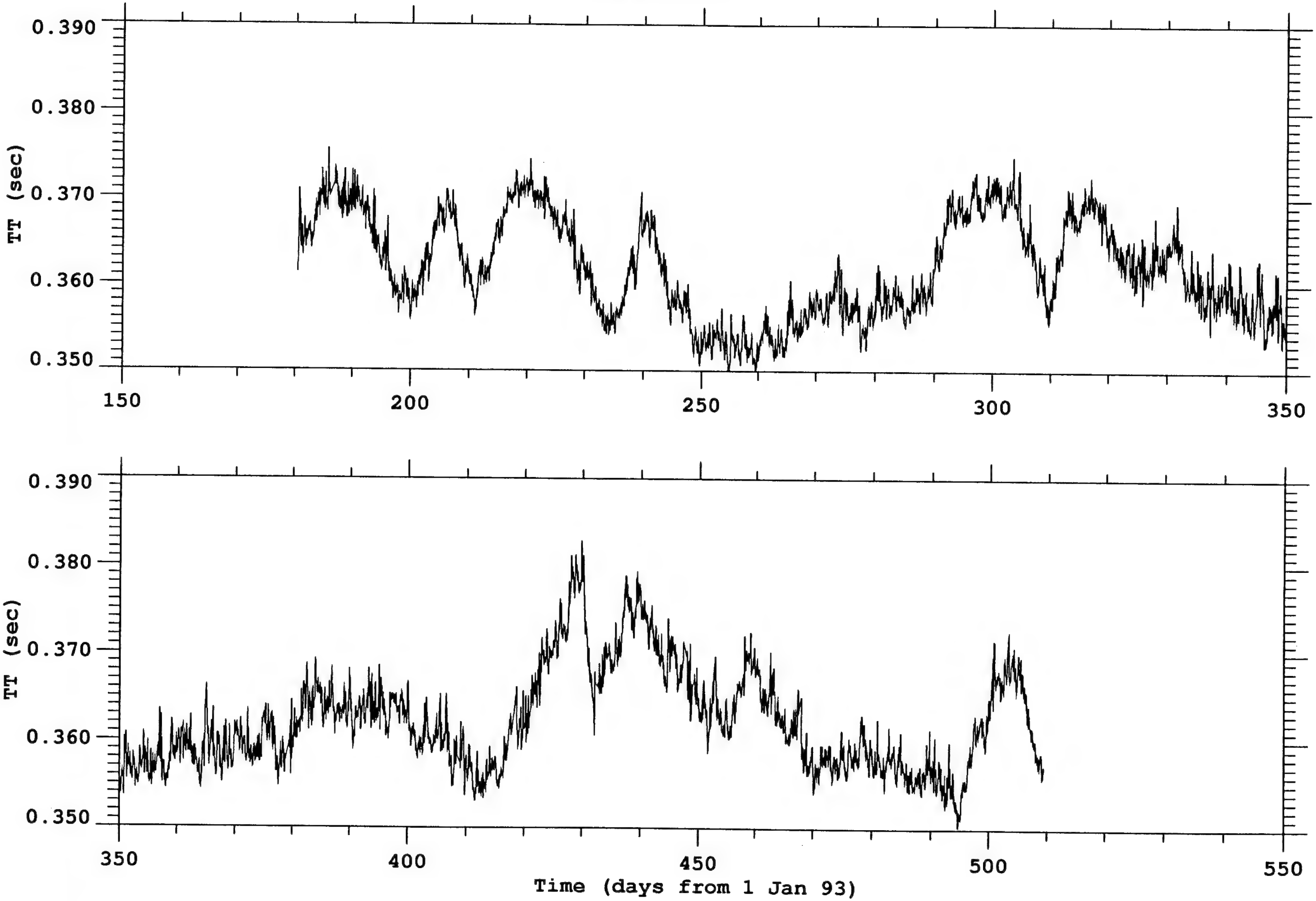
93IES4



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TT (sec)
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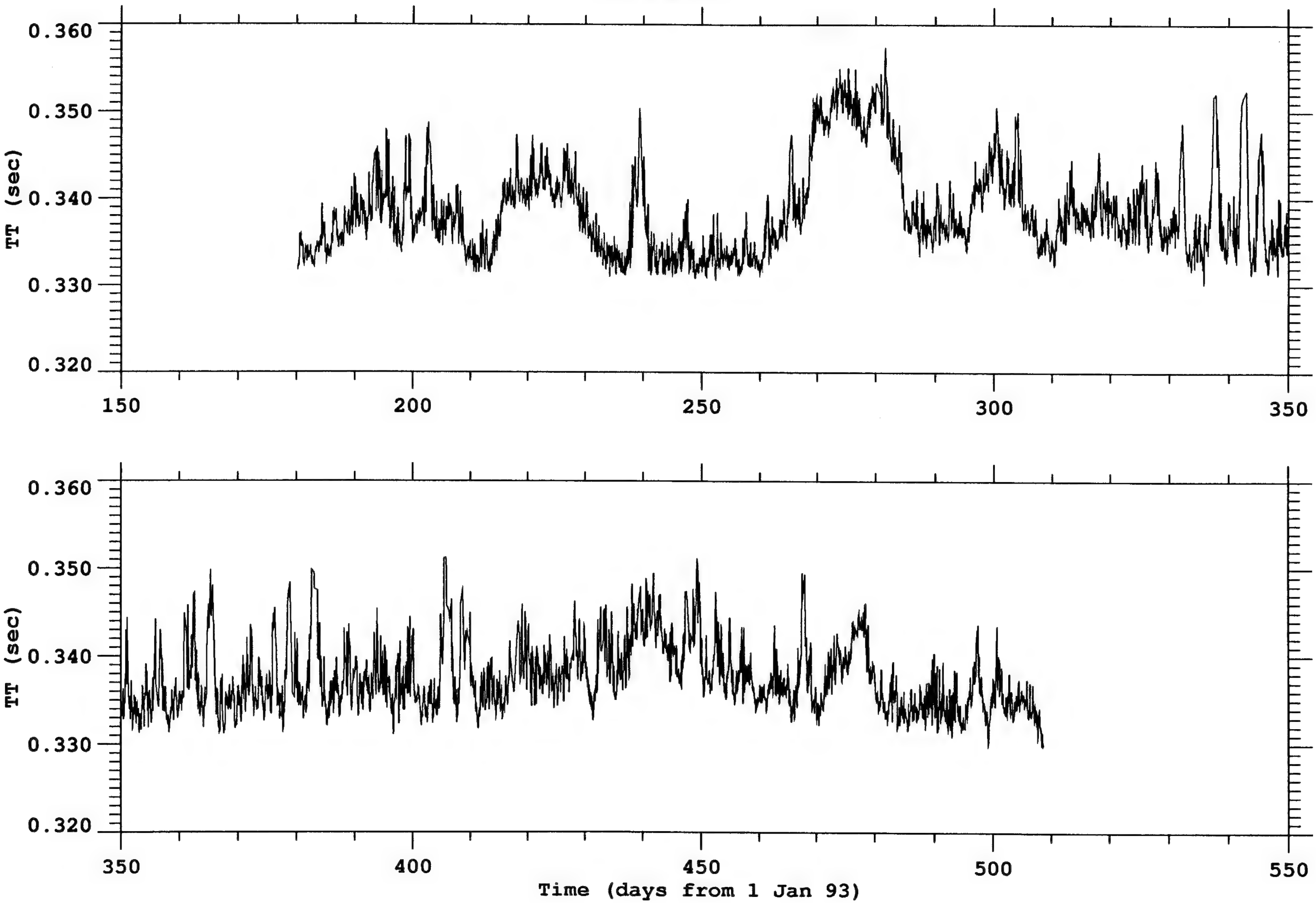
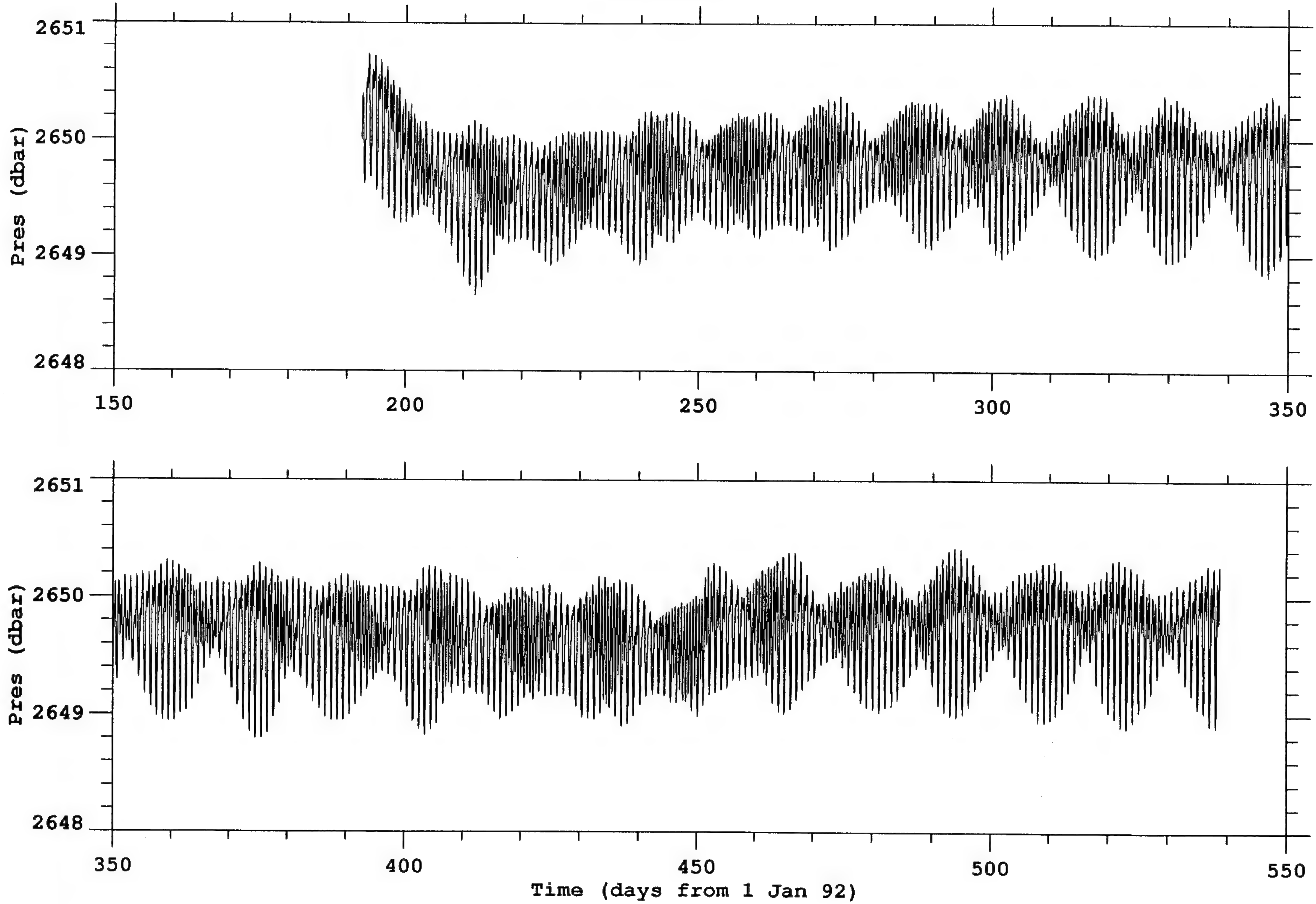
0.350
350
400
450
500
550
Time (days from 1 Jan 93)

93IES5



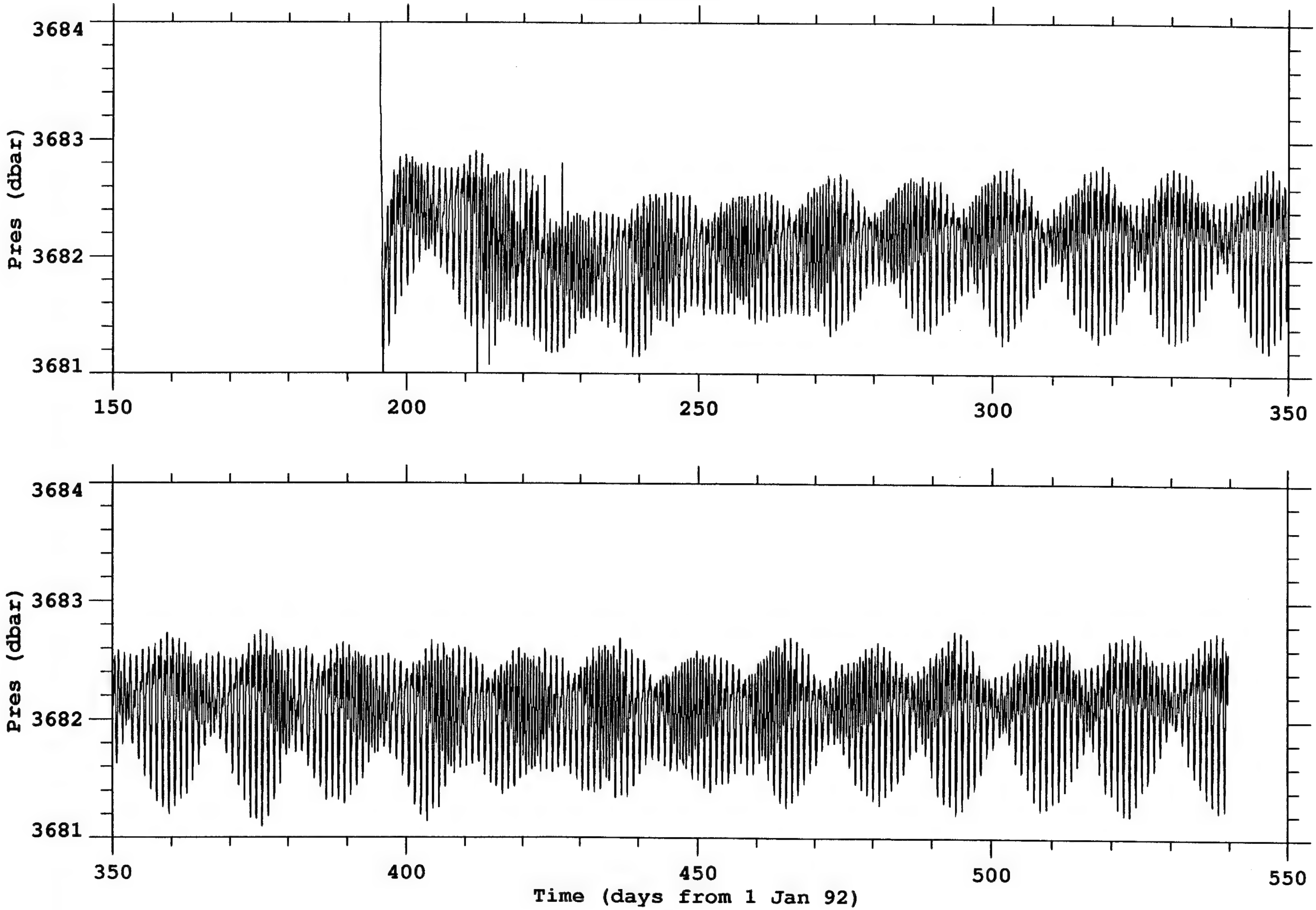
TT (sec)
0.360
0.350
0.340
0.330
0.320
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

92IES1



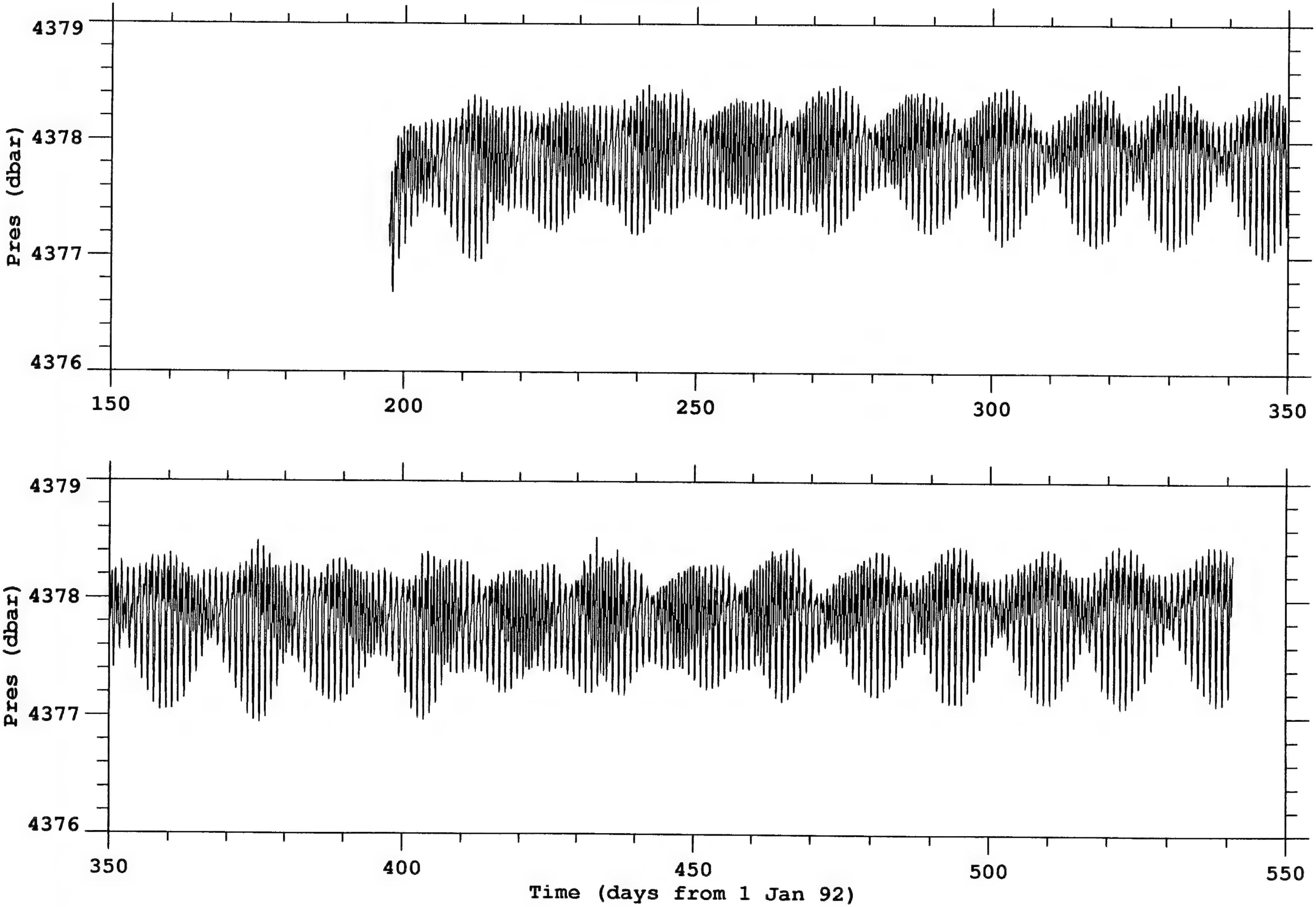
2651
2650
2649
2648
Pres (dbar)
150
200
250
300
350
2651
2650
2649
2648
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 92)

92IES2



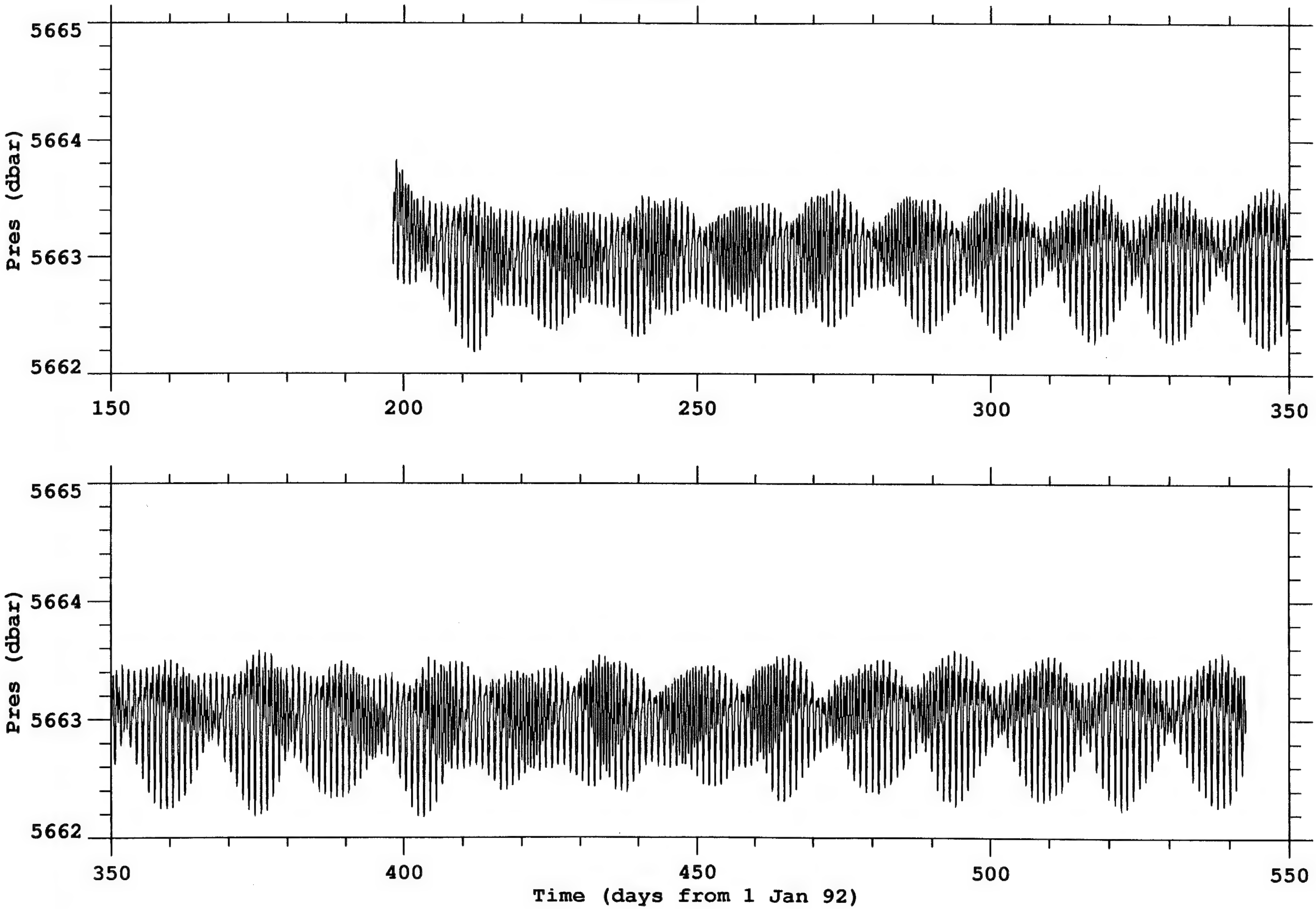
3684
3683
3682
3681
Pres (dbar)
150
200
250
300
350
3684
3683
3682
3681
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 92)

92IES3



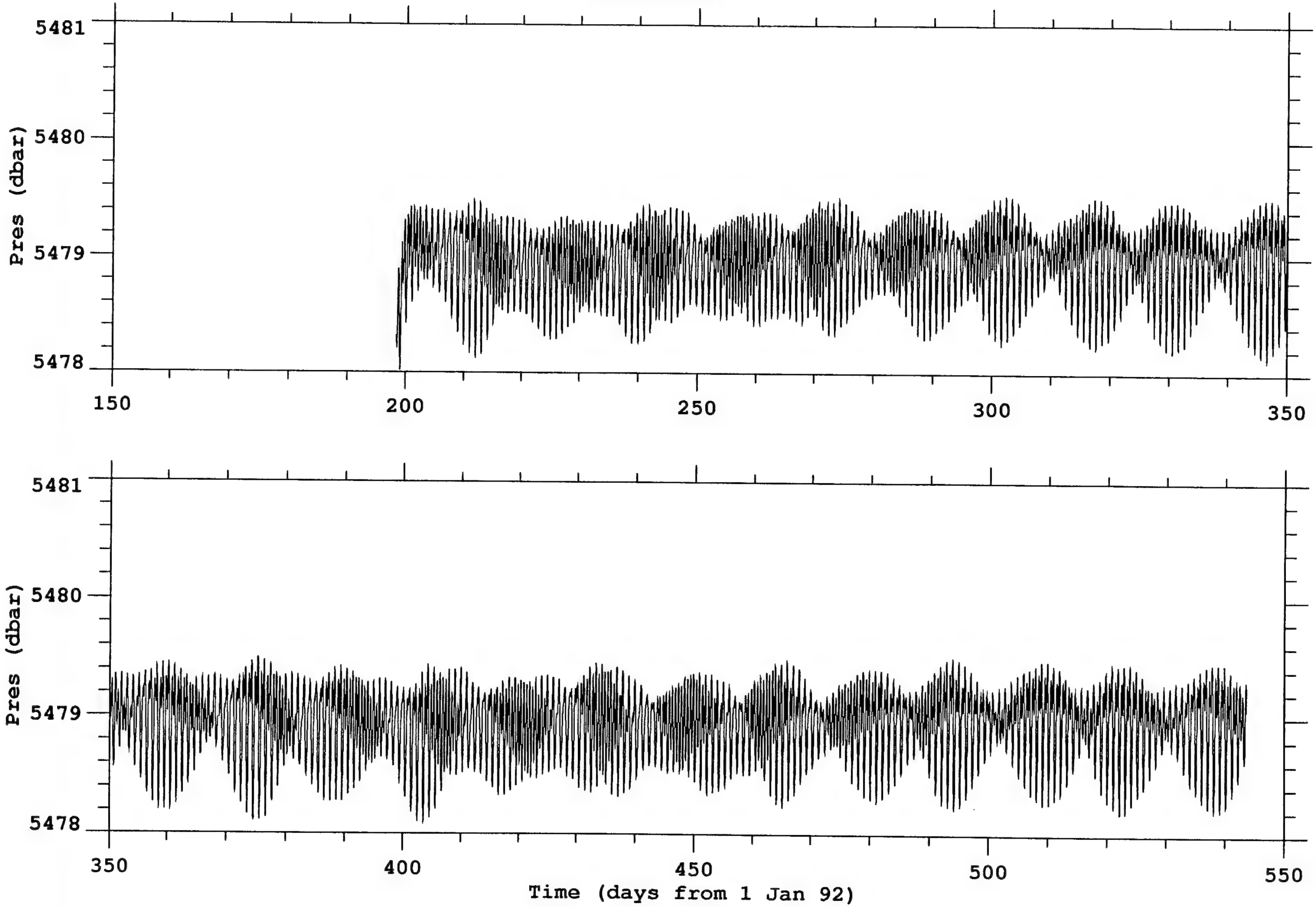
4379
4378
4377
4376
Pres (dbar)
150
200
250
300
350
4379
4378
4377
4376
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 92)

92IES4

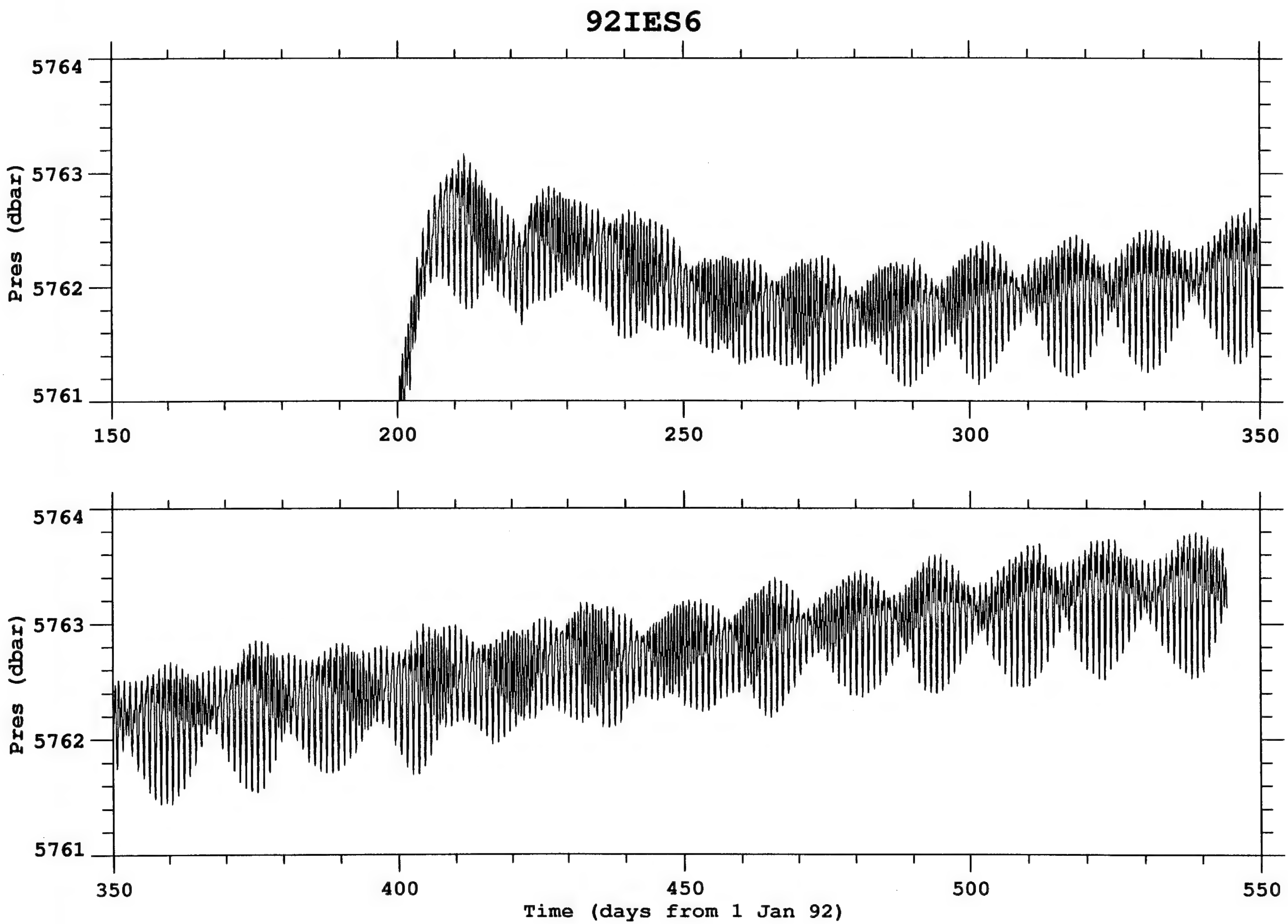


5665
5664
5663
5662
Pres (dbar)
150
200
250
300
350
5665
5664
5663
5662
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 92)

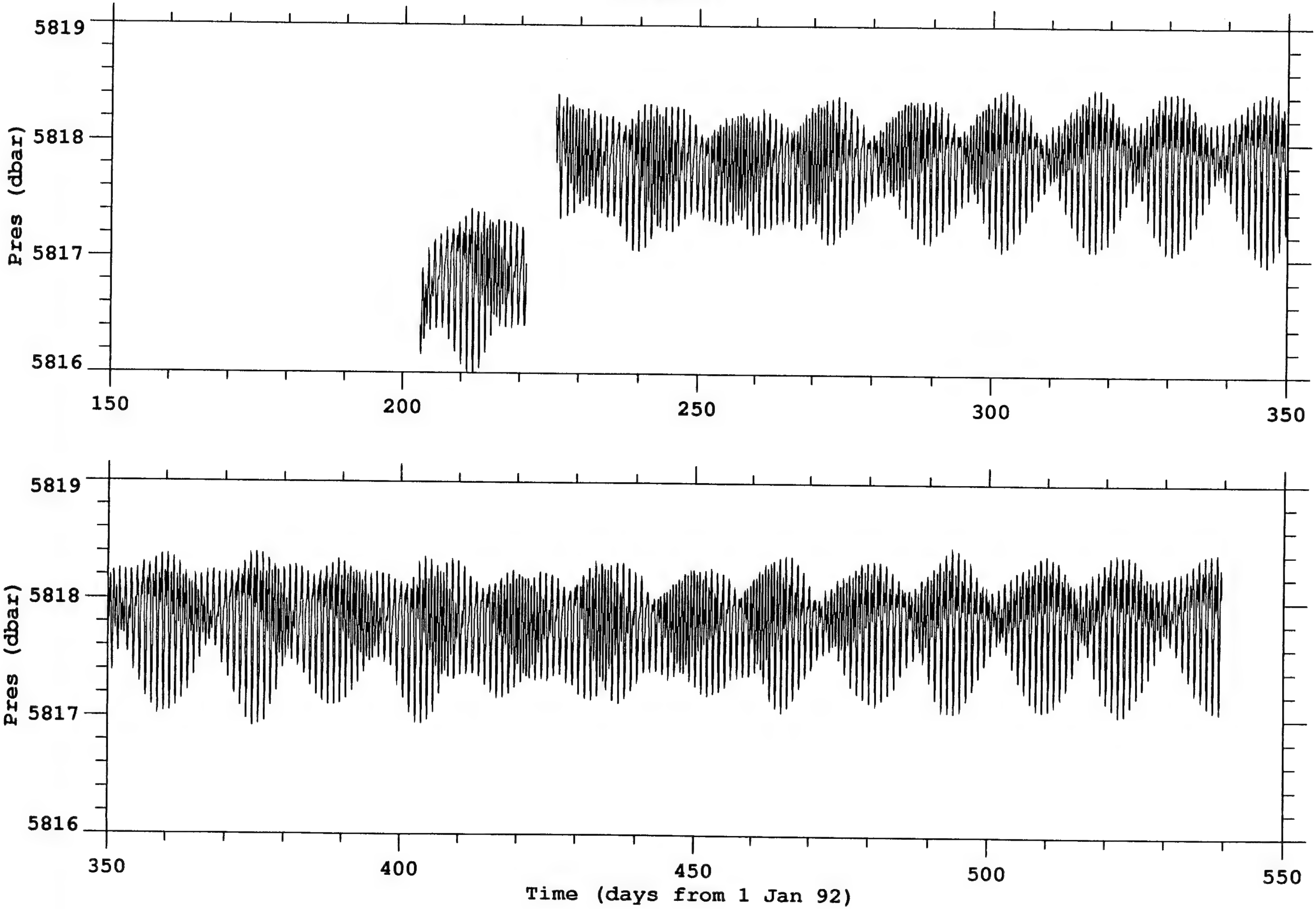
92IES5



5481
5480
5479
5478
Pres (dbar)
150
200
250
300
350
5481
5480
5479
5478
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 92)

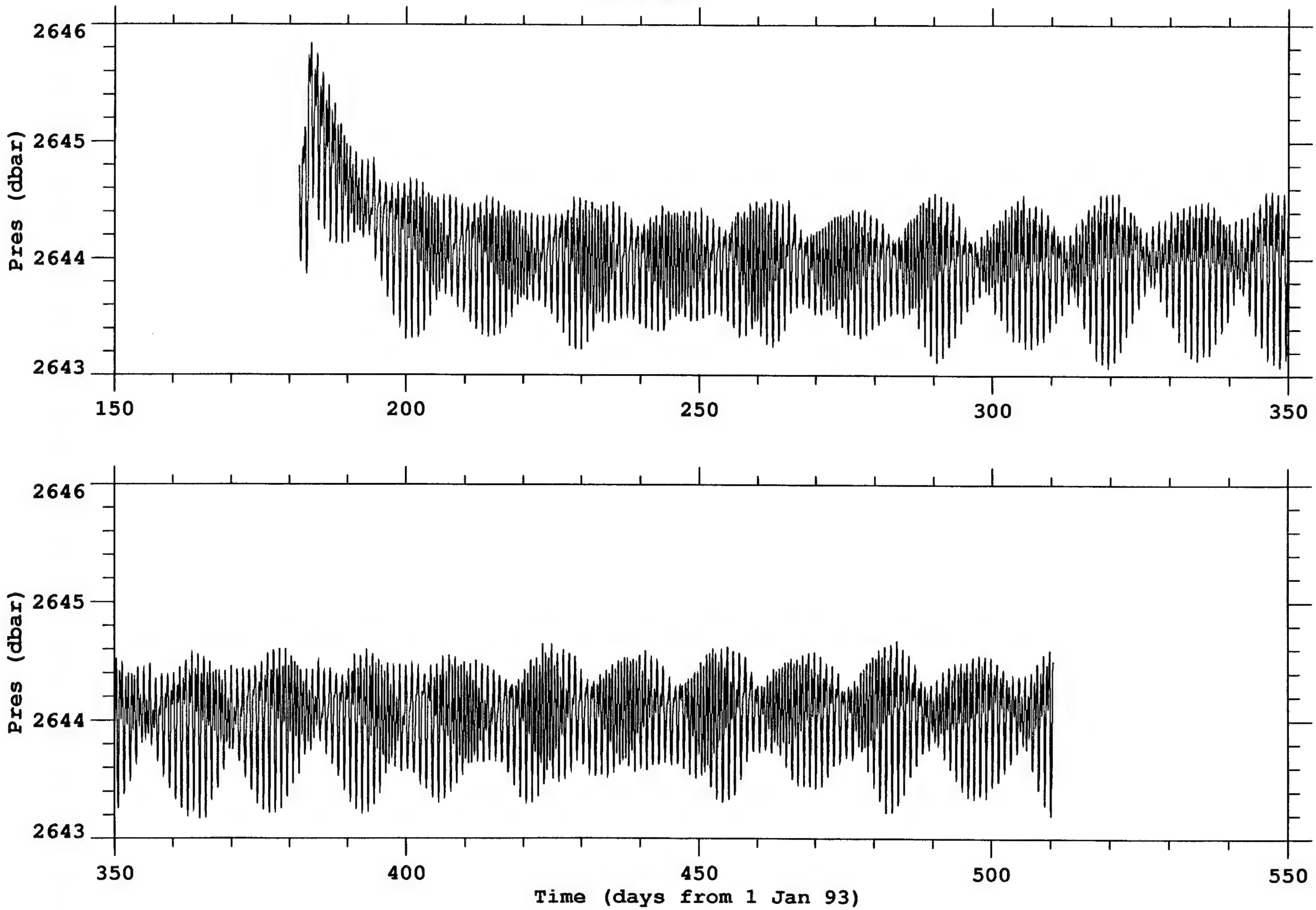

92IES6
Pres (dbar)
5764
5763
5762
5761
150
200
250
300
350
Pres (dbar)
5764
5763
5762
5761
350
400
450
500
550
Time (days from 1 Jan 92)

92IES7

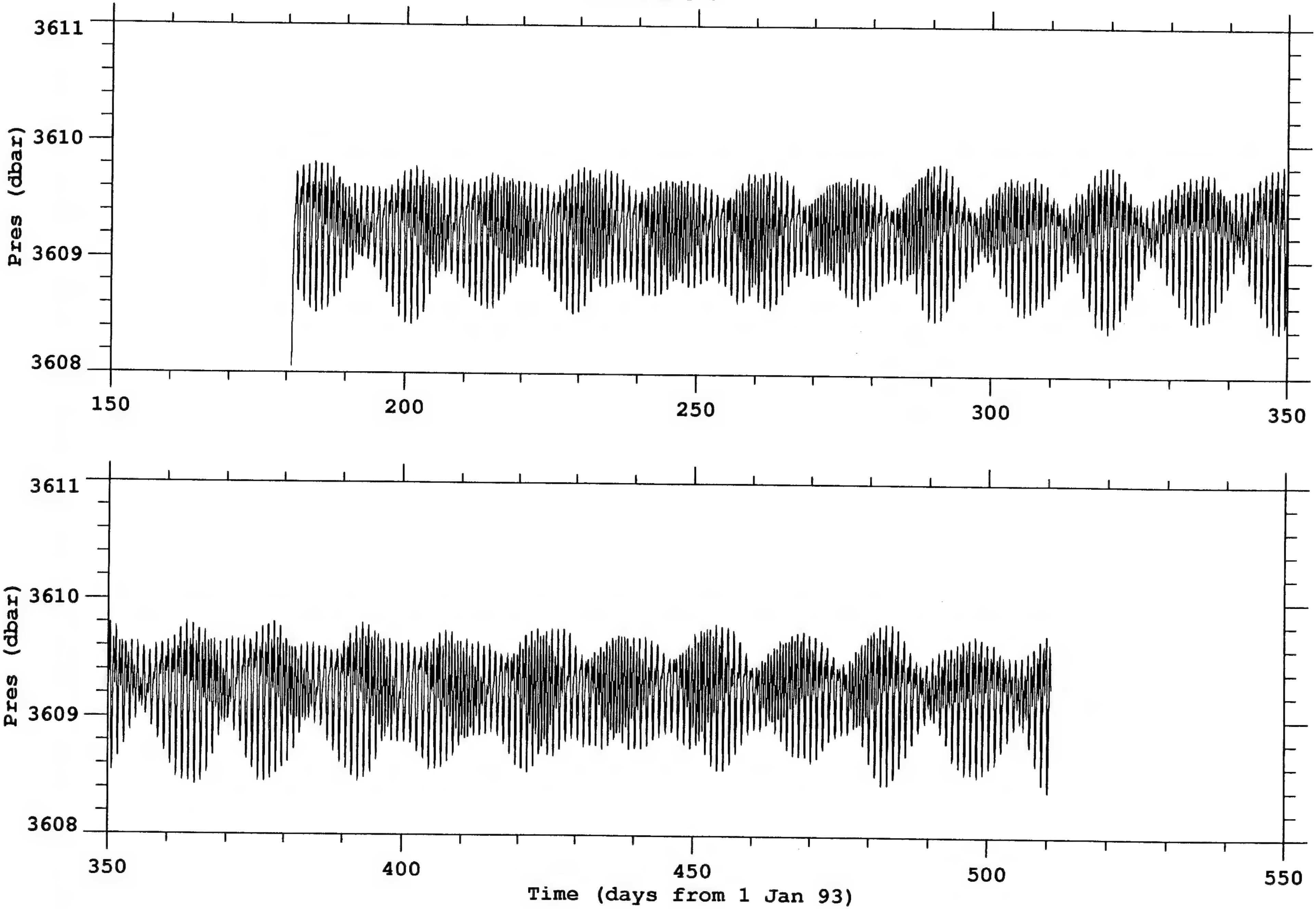


5819
5818
5817
5816
Pres (dbar)
150
200
250
300
350
5819
5818
5817
5816
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 92)

93IES1

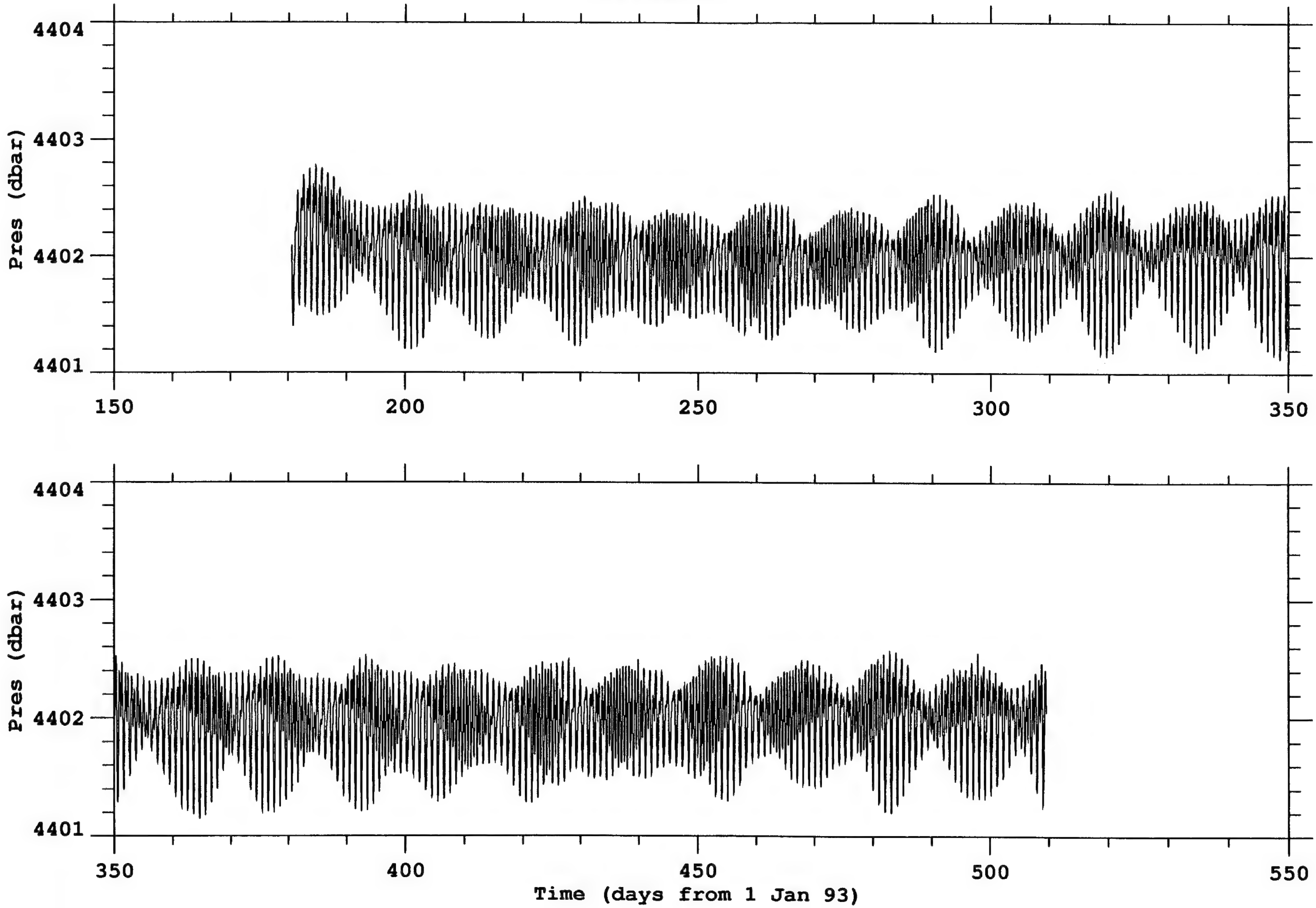

2646
2645
2644
2643
Pres (dbar)
150
200
250
300
350
2646
2645
2644
2643
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 93)

93IES2



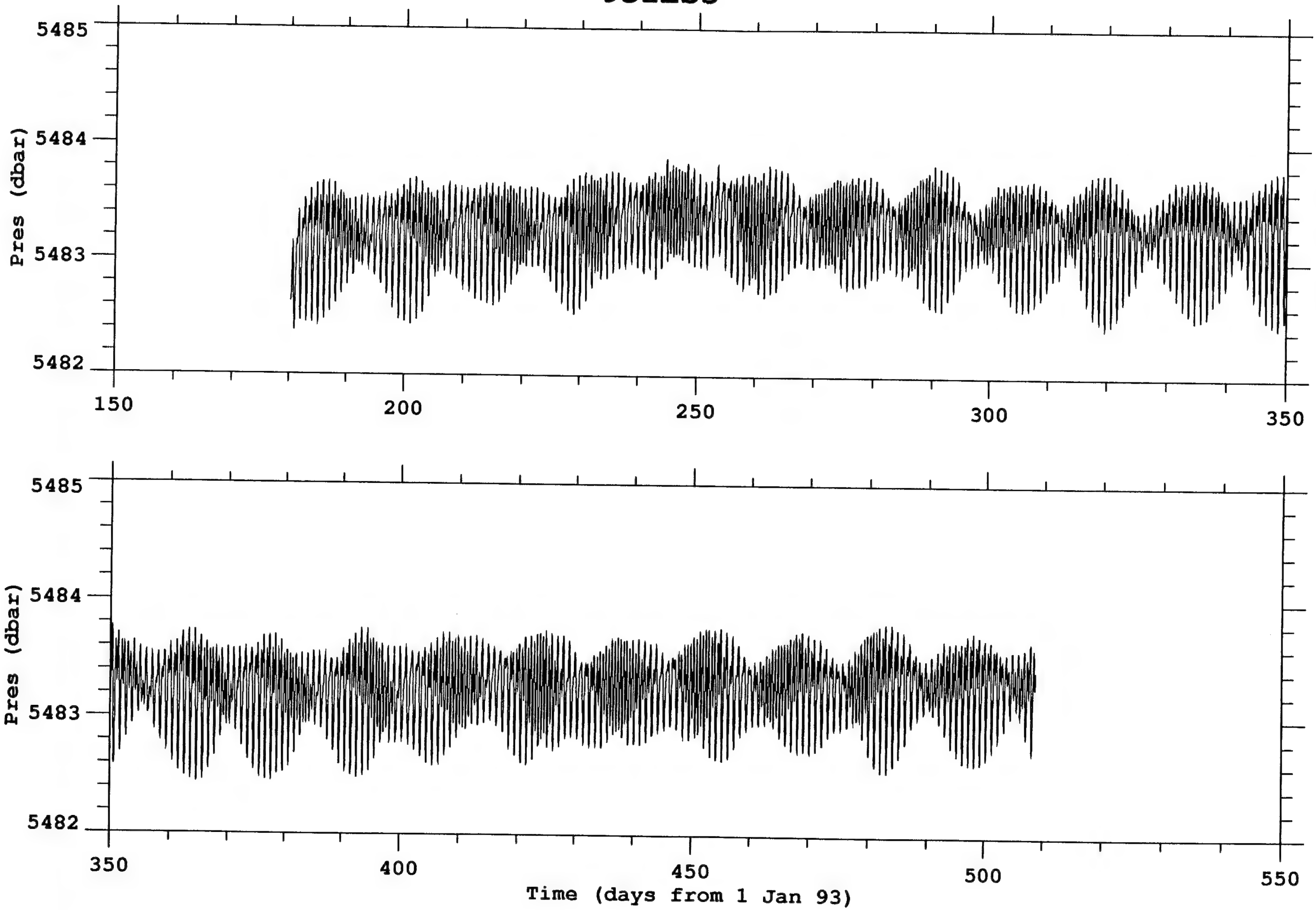
3611
3610
3609
3608
Pres (dbar)
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

93IES3

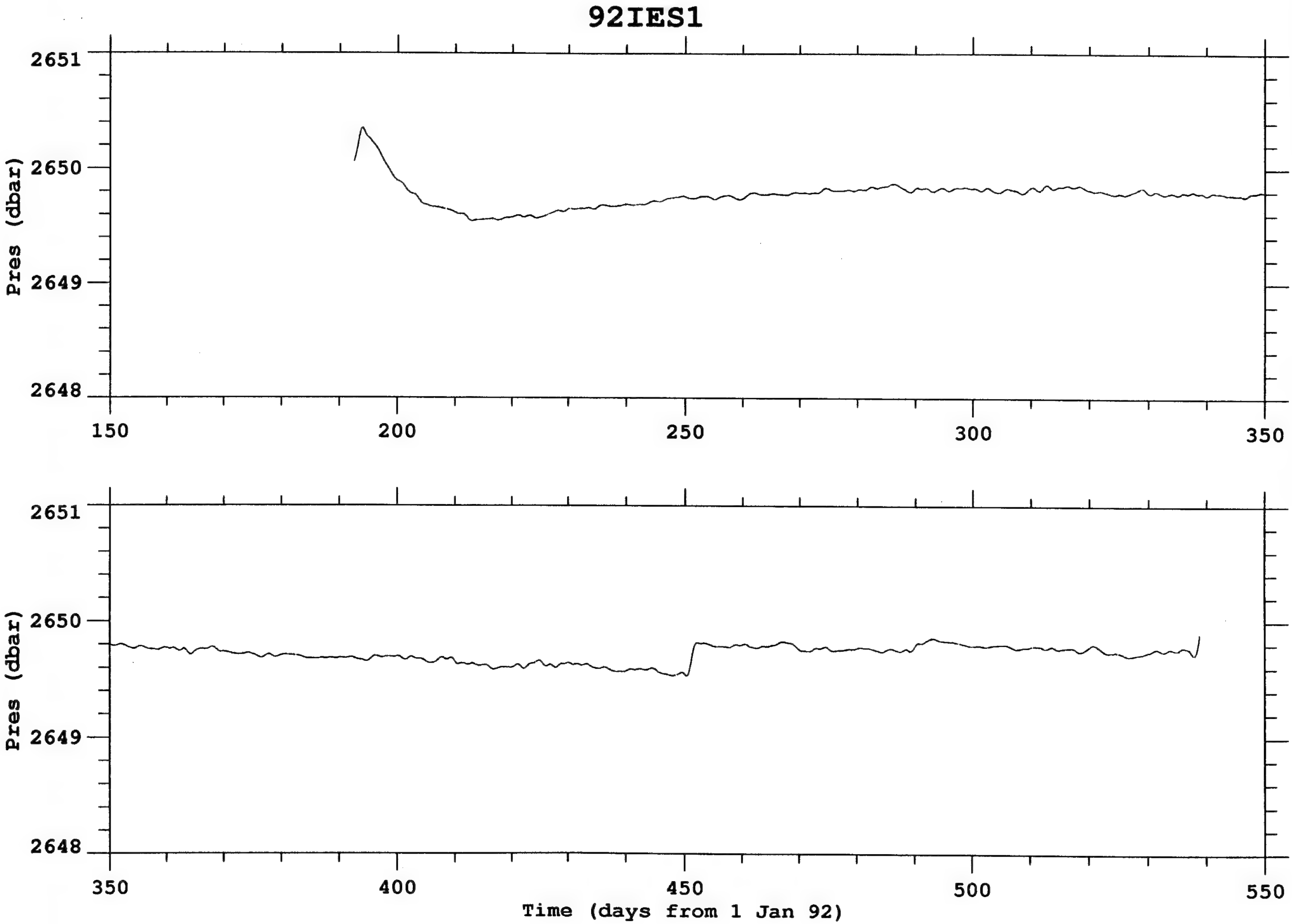


4404
4403
4402
4401
Pres (dbar)
150
200
250
300
350
4404
4403
4402
4401
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 93)

93IES5

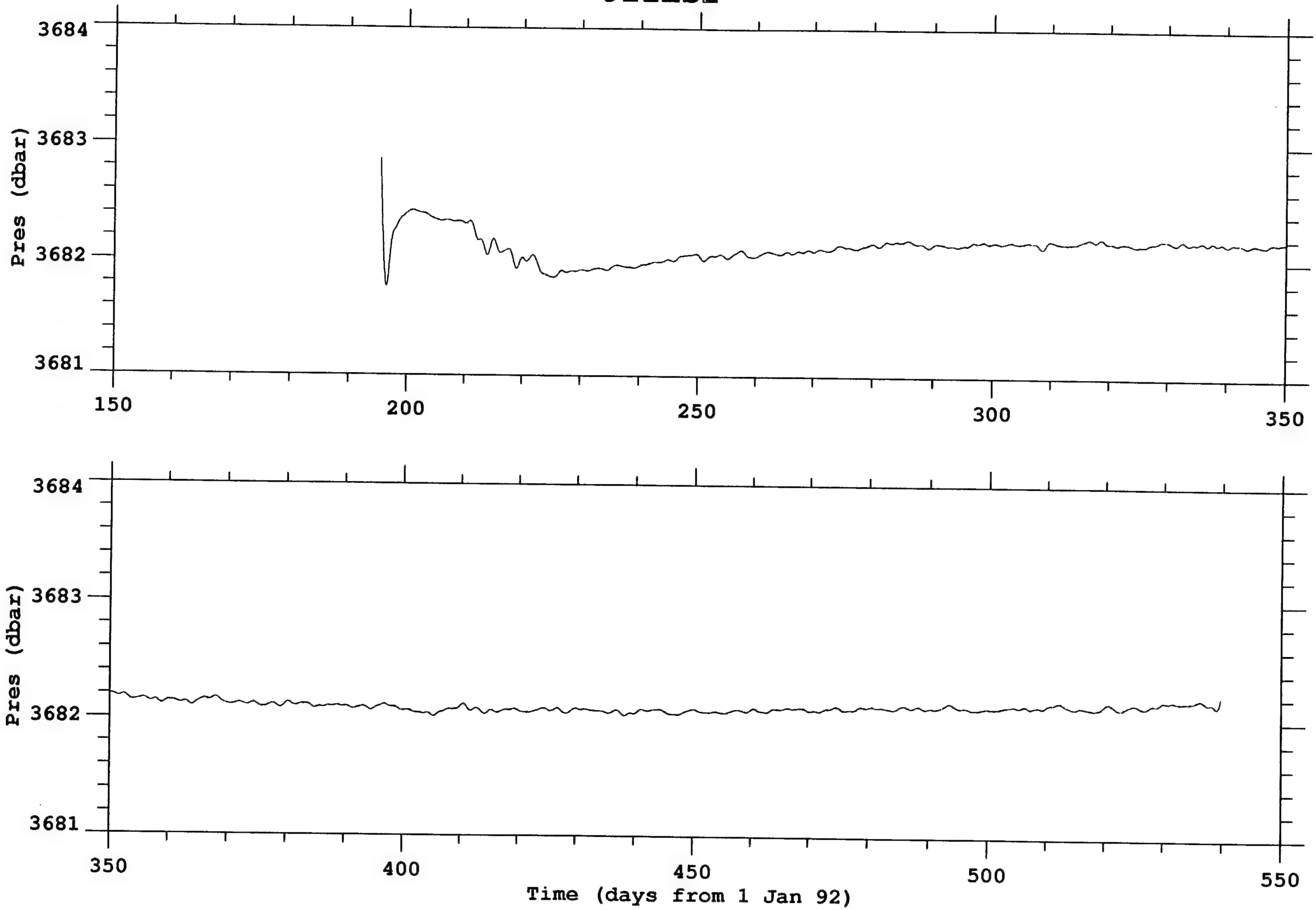


5485
5484
5483
5482
Pres (dbar)
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)



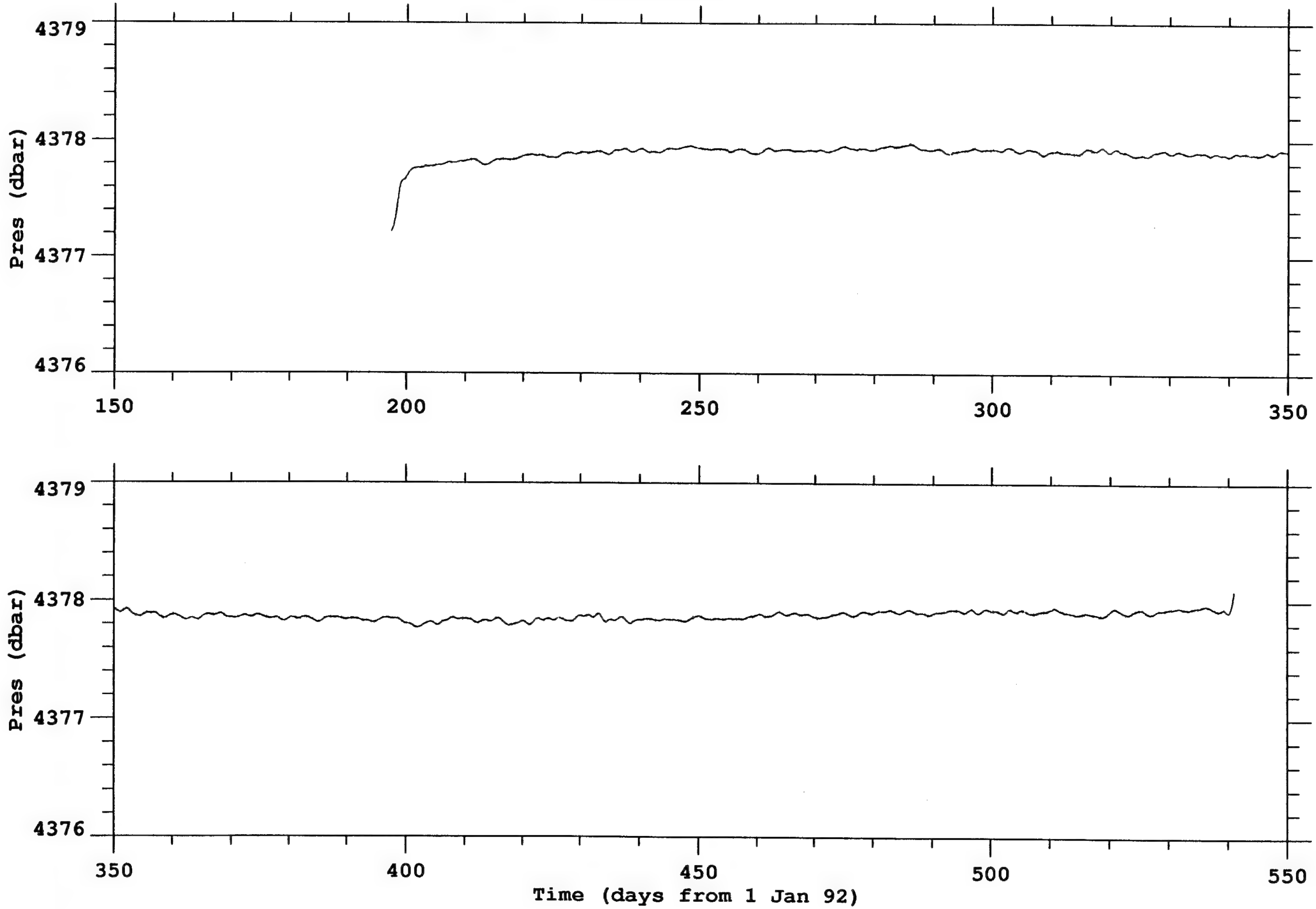
92IES1
Pres (dbar)
2651
2650
2649
2648
150
200
250
300
350
Pres (dbar)
2651
2650
2649
2648
350
400
450
500
550
Time (days from 1 Jan 92)

92IES2



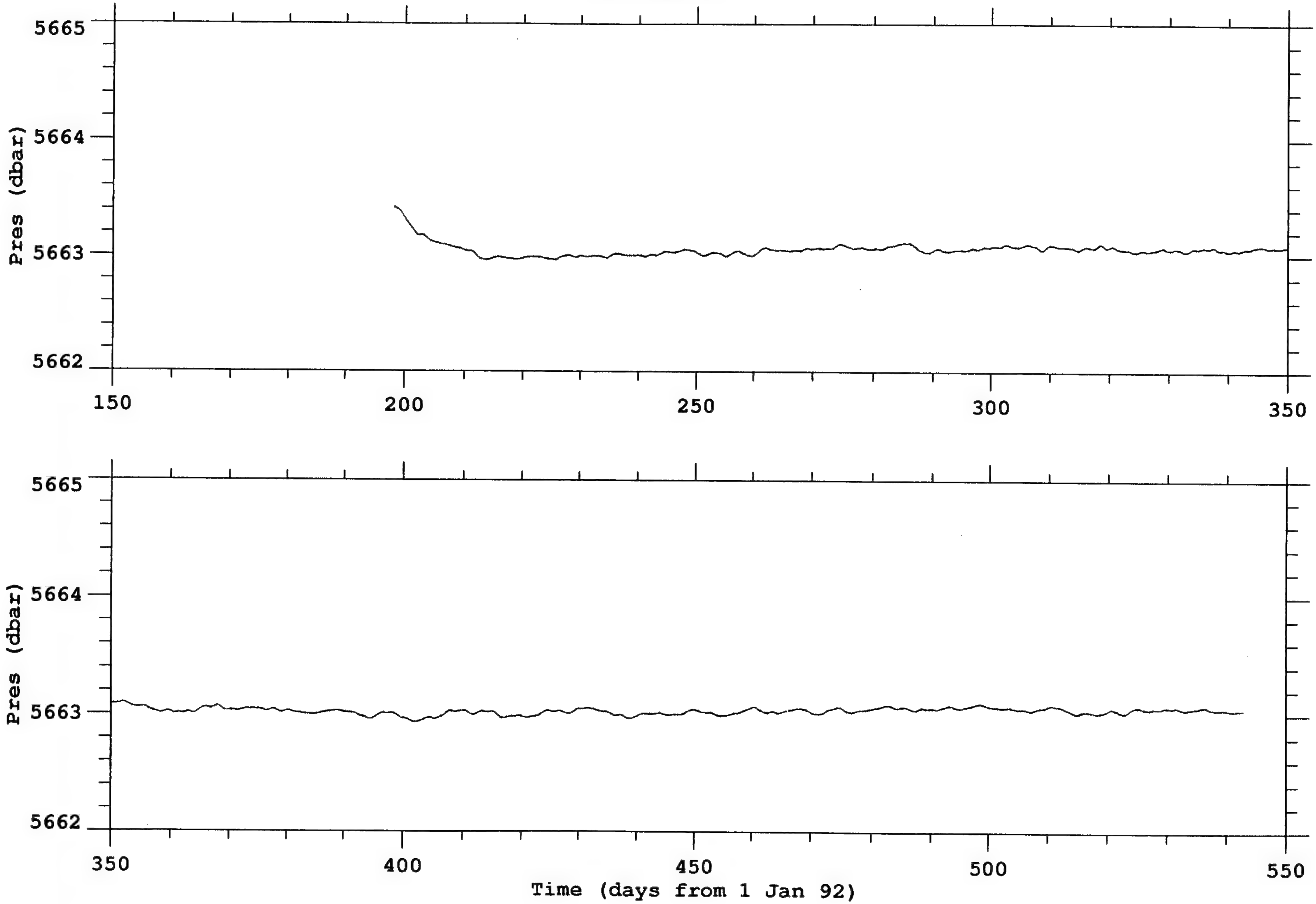
3684
3683
3682
3681
Pres (dbar)
150
200
250
300
350
3684
3683
3682
3681
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 92)

92IES3

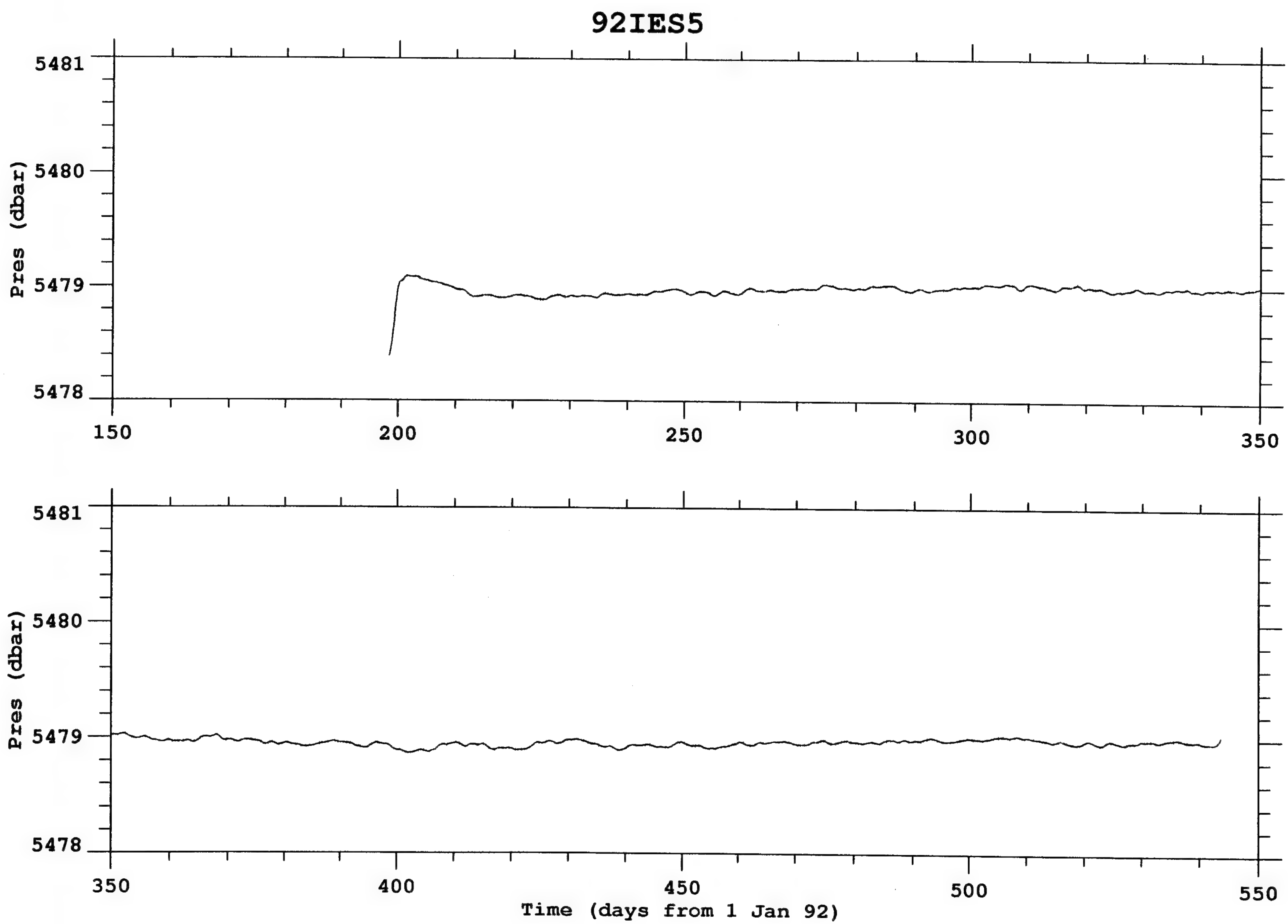


4379
4378
4377
4376
Pres (dbar)
150
200
250
300
350
4379
4378
4377
4376
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 92)

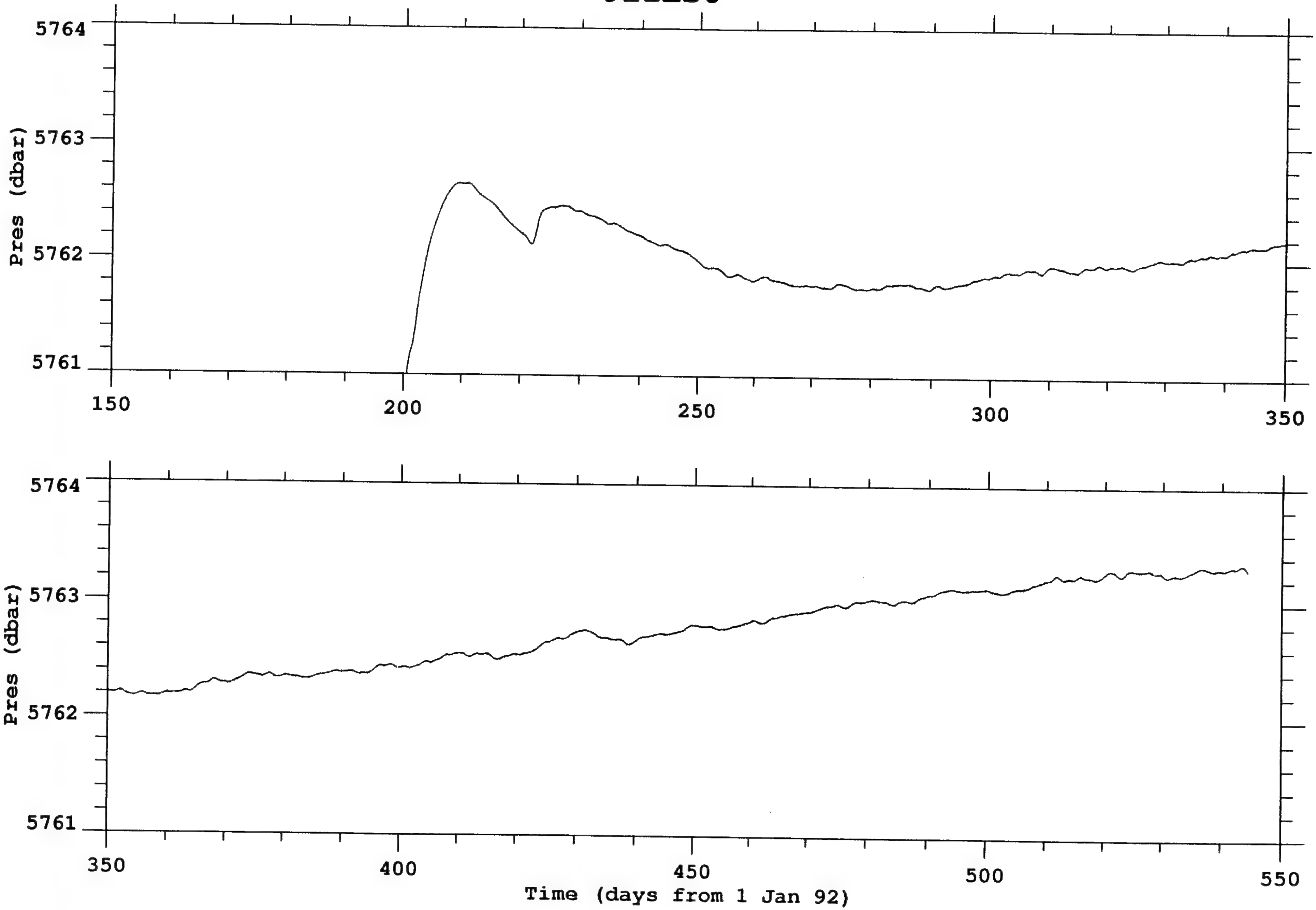
92IES4



Pres (dbar)
5665
5664
5663
5662
150
200
250
300
350
Pres (dbar)
5665
5664
5663
5662
350
400
450
500
550
Time (days from 1 Jan 92)

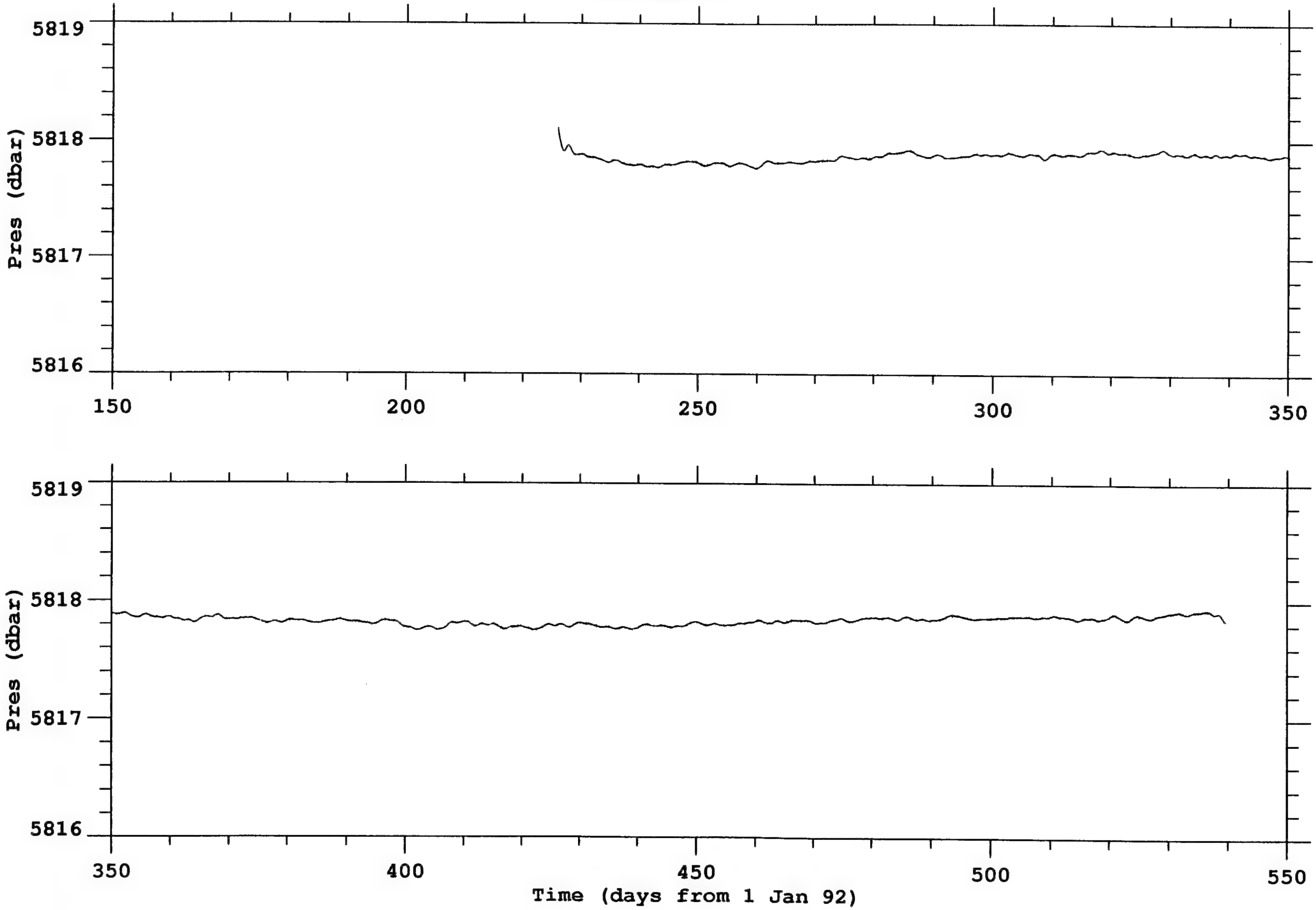

92IES5
Pres (dbar)
5481
5480
5479
5478
150
200
250
300
350
Pres (dbar)
5481
5480
5479
5478
350
400
450
500
550
Time (days from 1 Jan 92)

92IES6



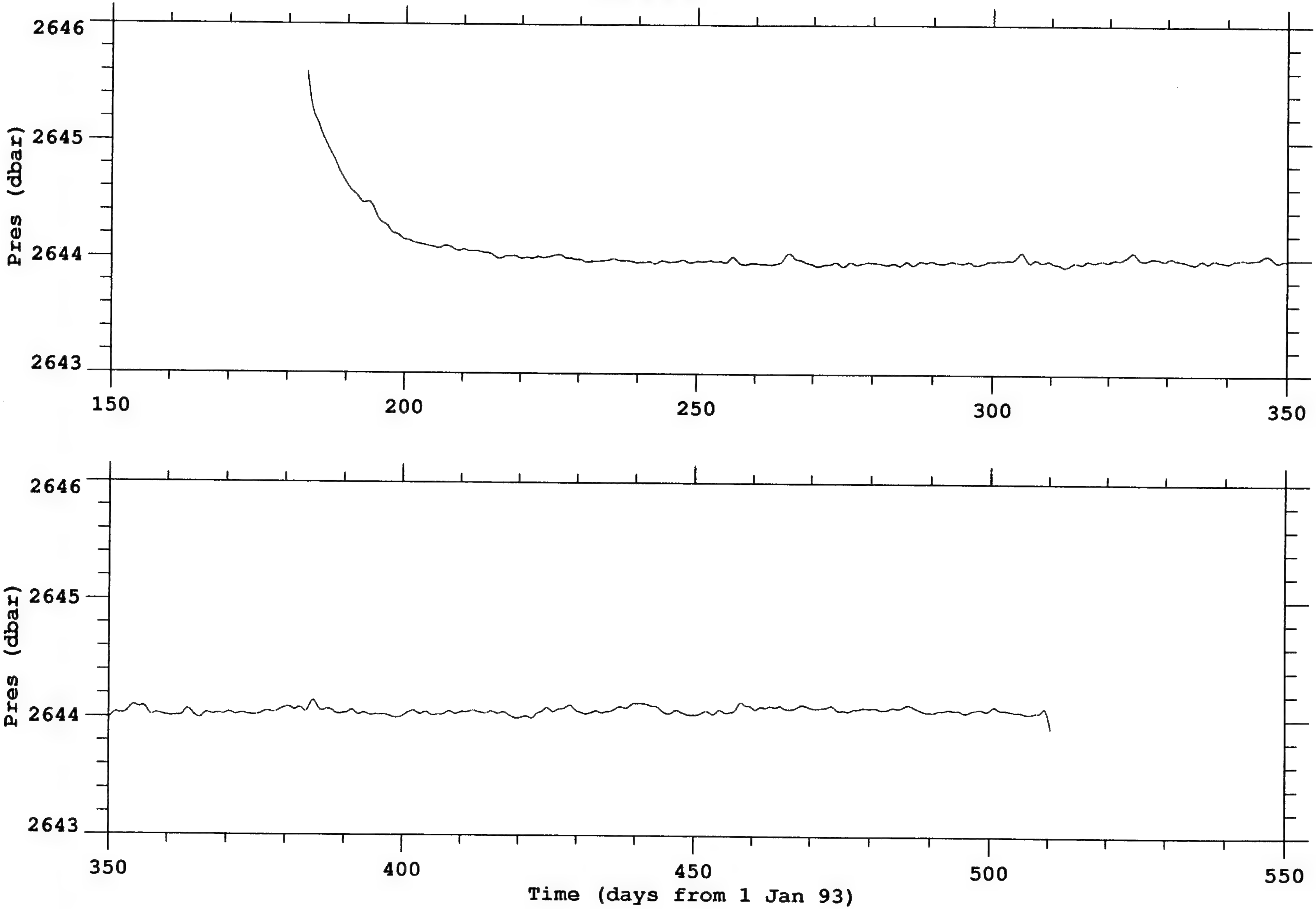
Pres (dbar)
5764
5763
5762
5761
150
200
250
300
350
Pres (dbar)
5764
5763
5762
5761
350
400
450
500
550
Time (days from 1 Jan 92)

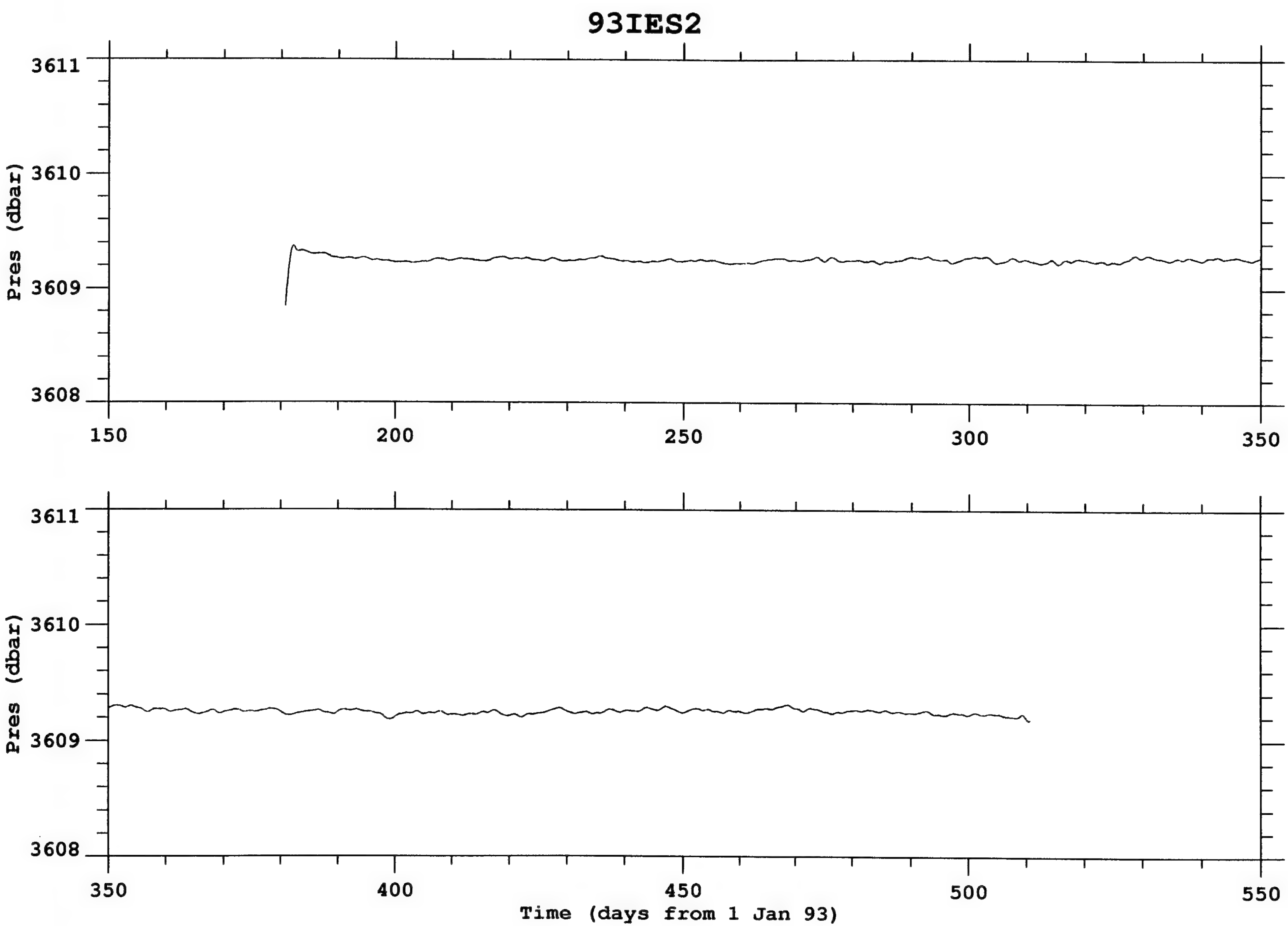
92IES7



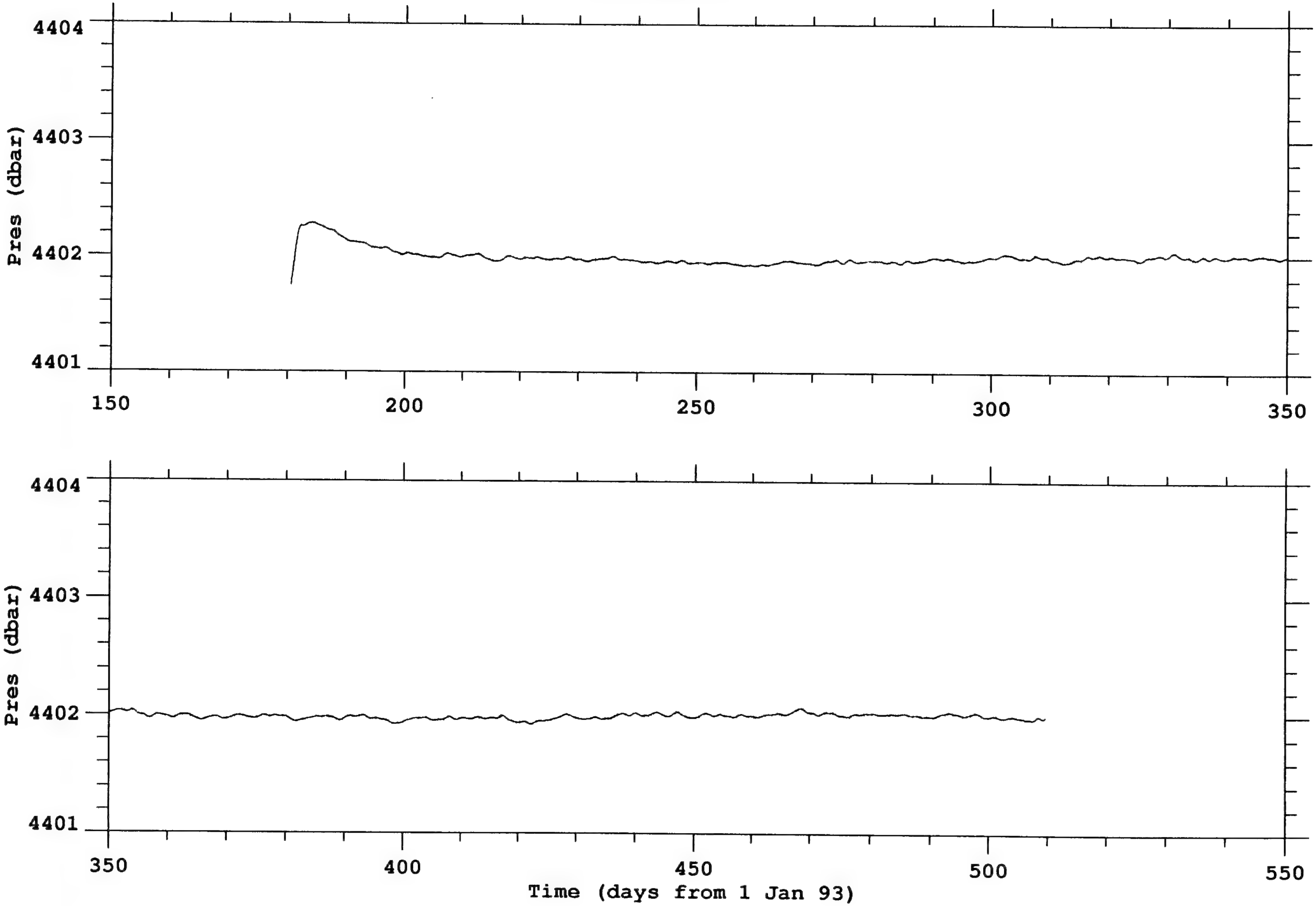
5819
5818
5817
5816
Pres (dbar)
150
200
250
300
350
5819
5818
5817
5816
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 92)

93IES1


2646
2645
2644
2643
Pres (dbar)
150
200
250
300
350
2646
2645
2644
2643
Pres (dbar)
350
400
450
500
550
Time (days from 1 Jan 93)

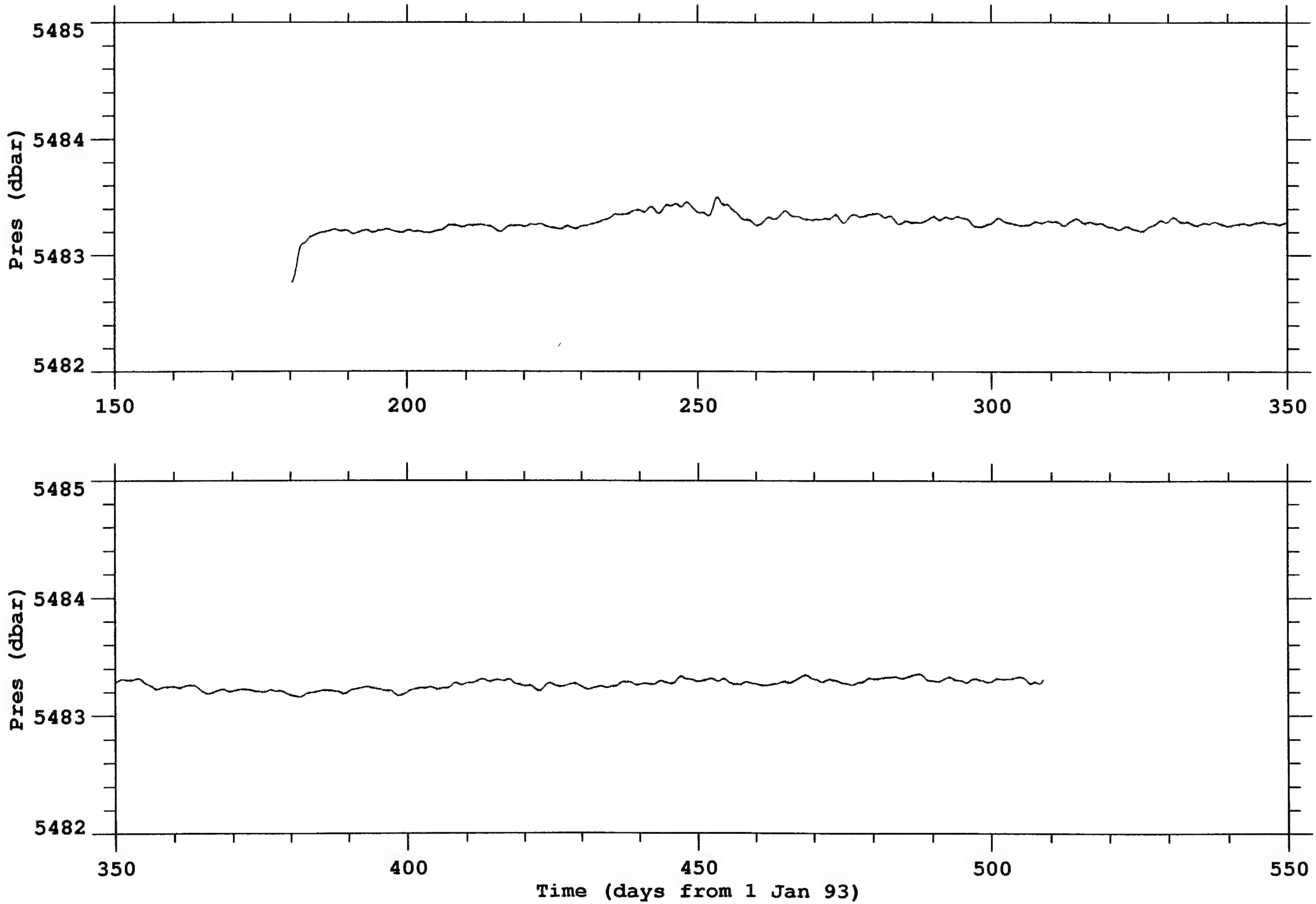

93IES2
Pres (dbar)
3611
3610
3609
3608
150
200
250
300
350
Pres (dbar)
3611
3610
3609
3608
350
400
450
500
550
Time (days from 1 Jan 93)

93IES3



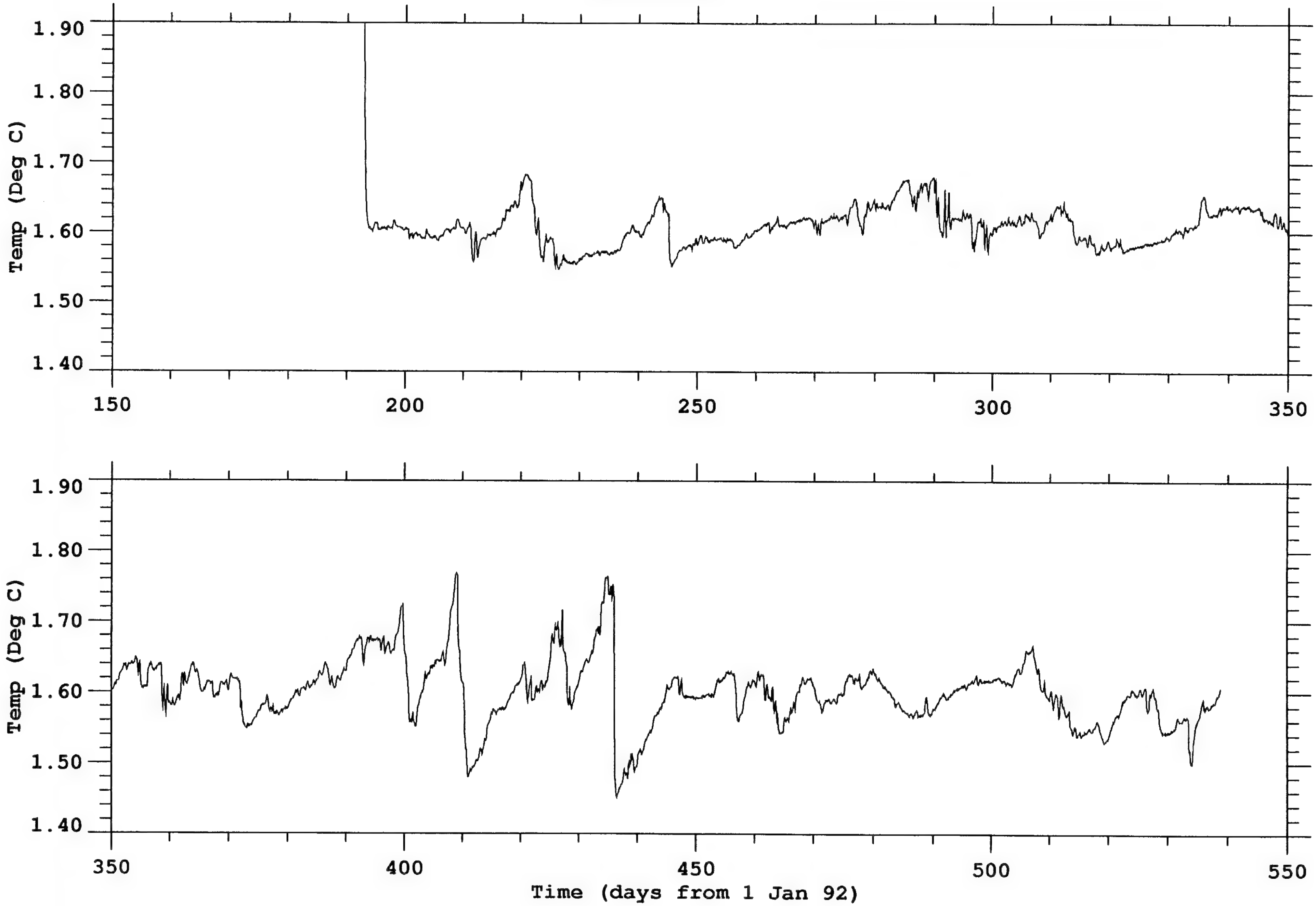
Pres (dbar)
4404
4403
4402
4401
150
200
250
300
350
4404
4403
4402
4401
350
400
450
500
550
Time (days from 1 Jan 93)

93IES5



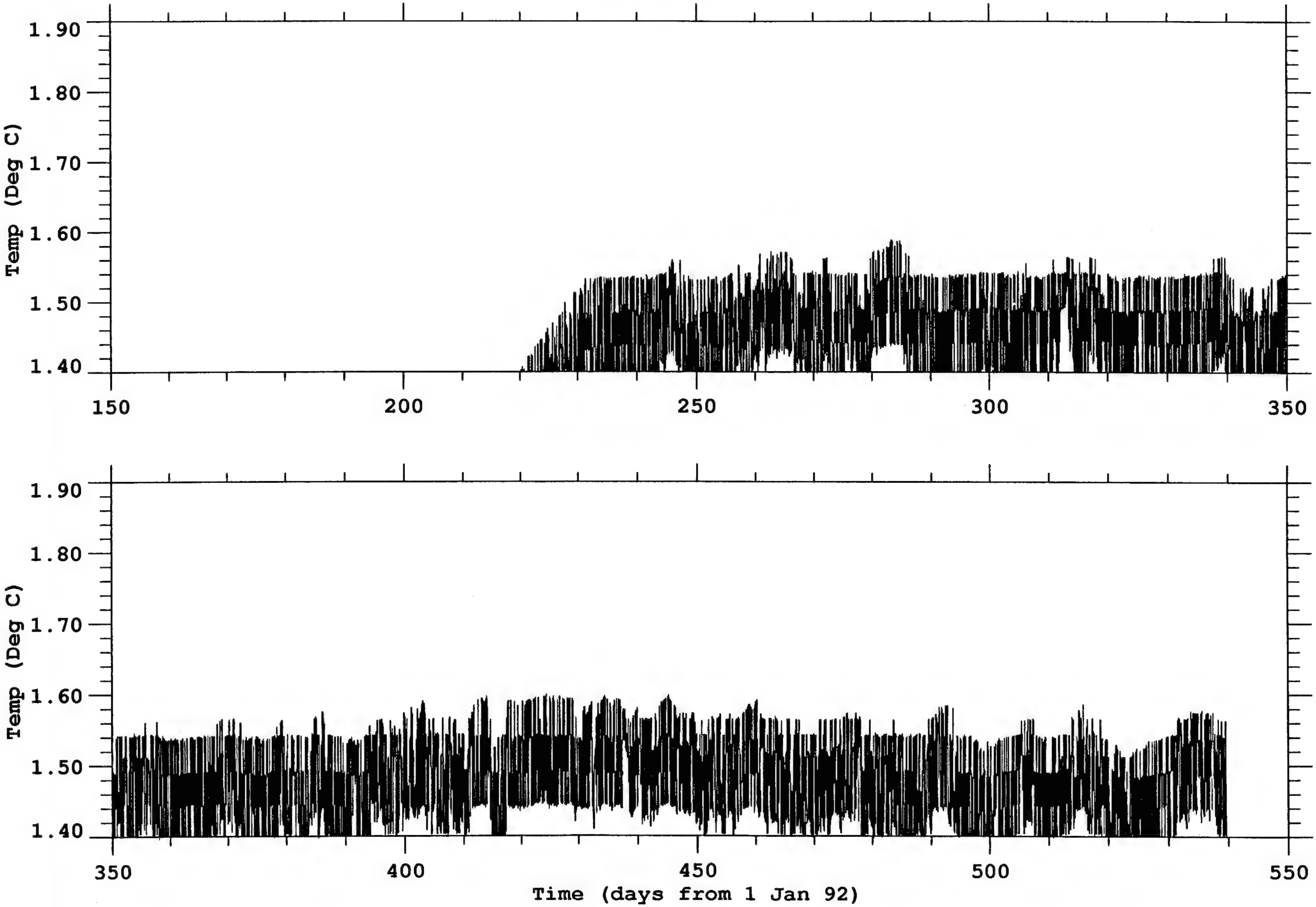
5485
5484
5483
5482
Pres (dbar)
150
200
250
300
350
550
400
450
500
Time (days from 1 Jan 93)

92IES1



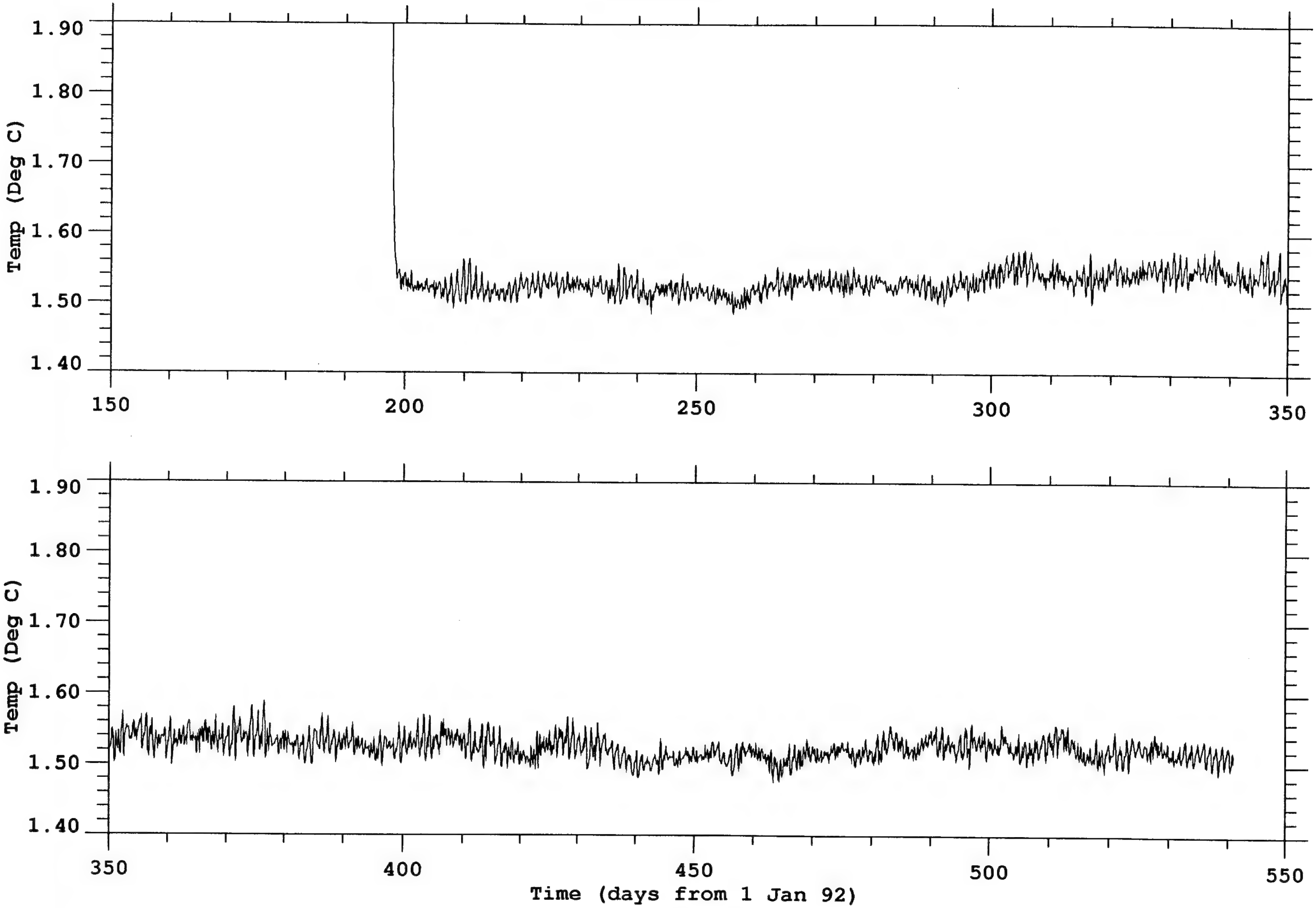
1.90
1.80
1.70
1.60
1.50
1.40
Temp (Deg C)
150
200
250
300
350
1.90
1.80
1.70
1.60
1.50
1.40
Temp (Deg C)
350
400
450
500
550
Time (days from 1 Jan 92)

92IES2

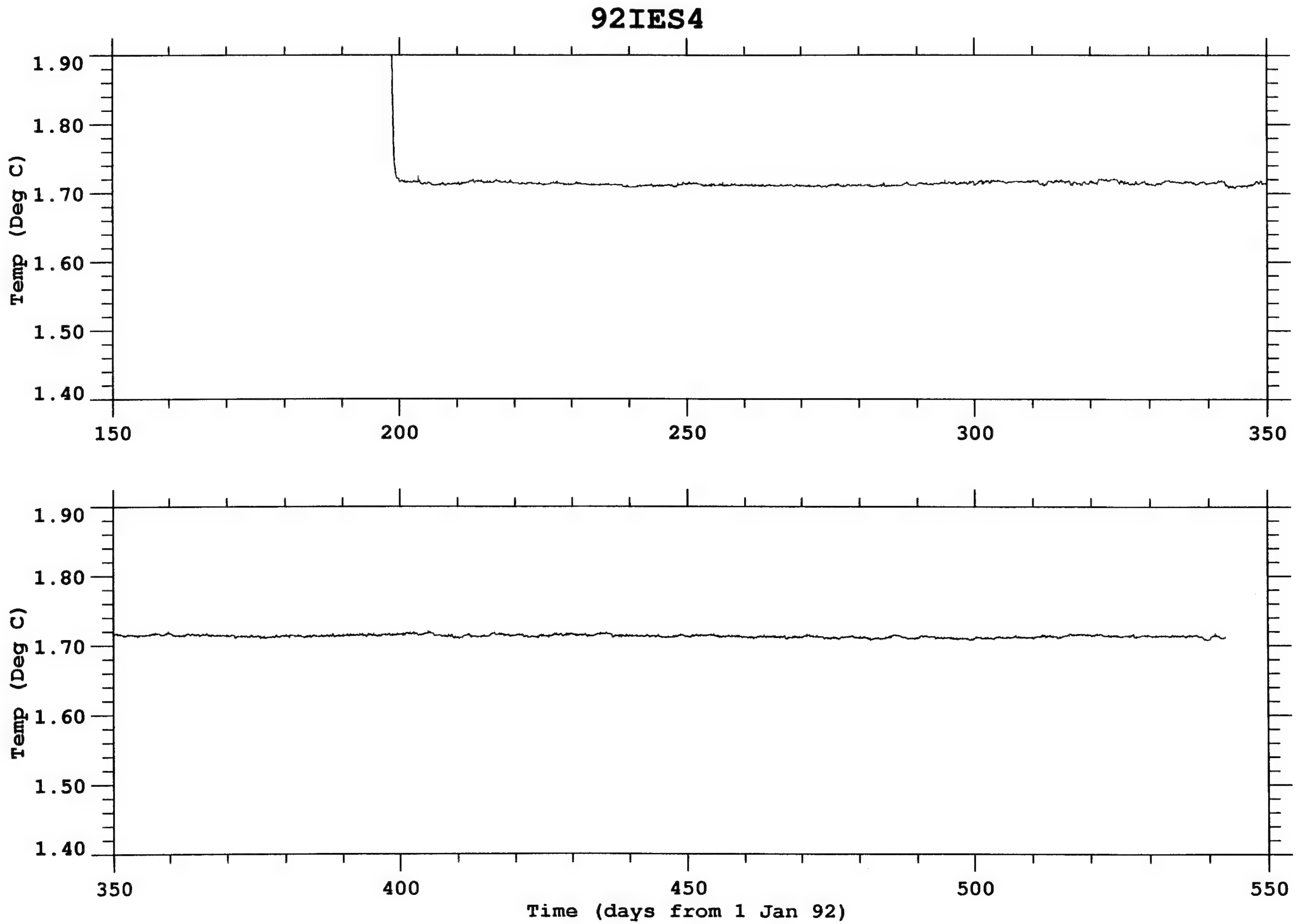


Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
150
200
250
300
350
550
400
450
500
Time (days from 1 Jan 92)

92IES3

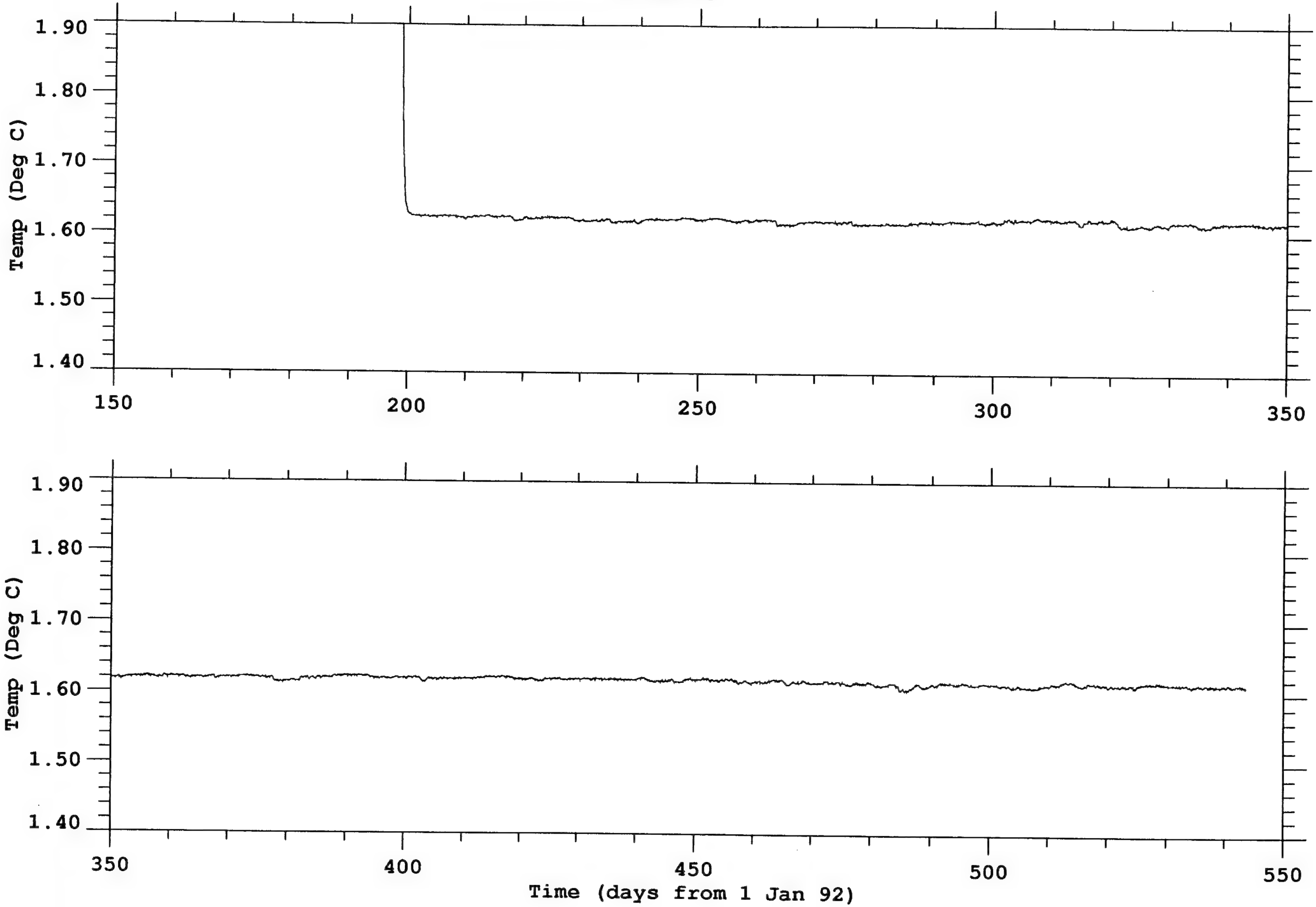


Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
150
200
250
300
350
Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
350
400
450
500
550
Time (days from 1 Jan 92)



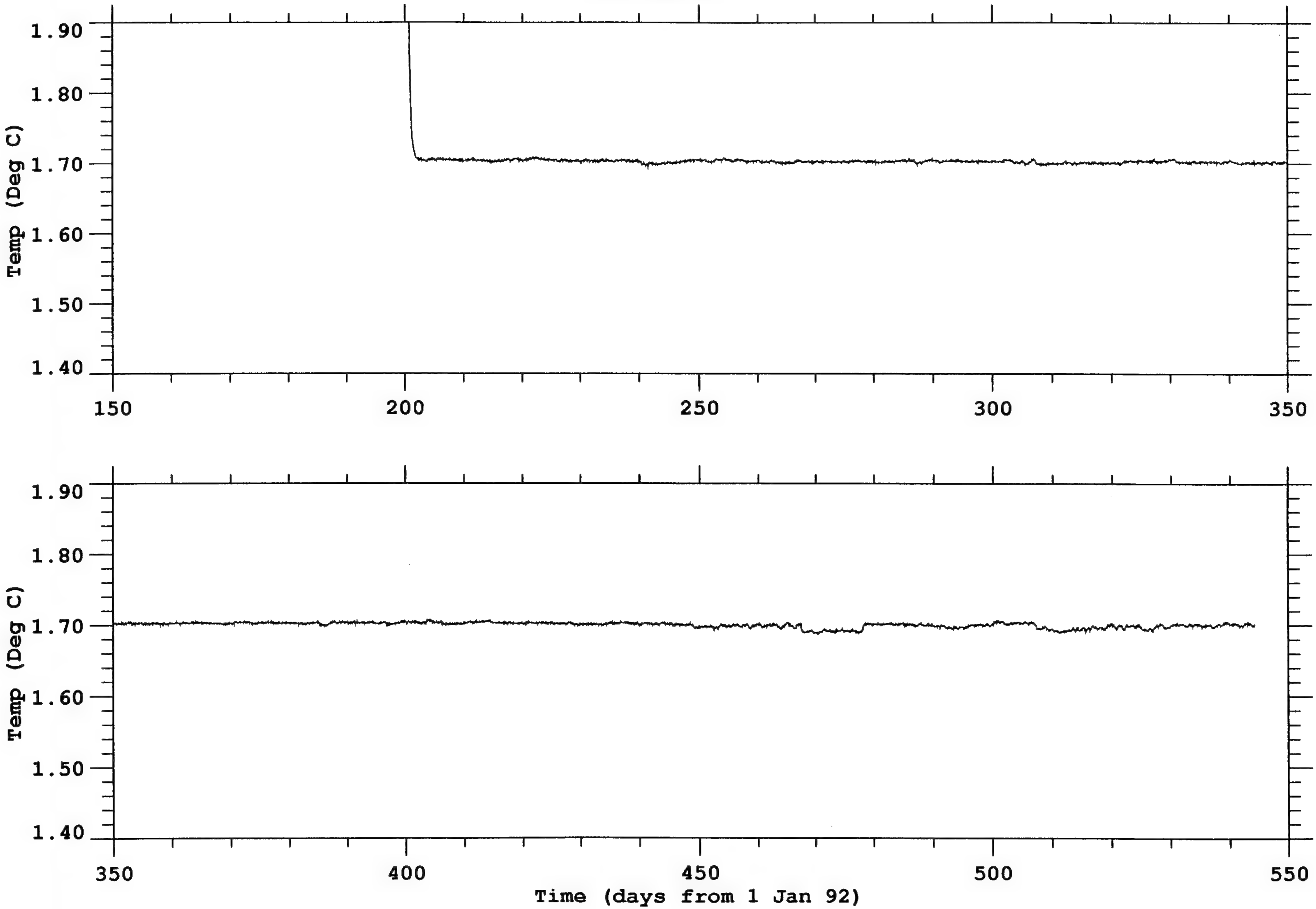
92IES4
Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

92IES5



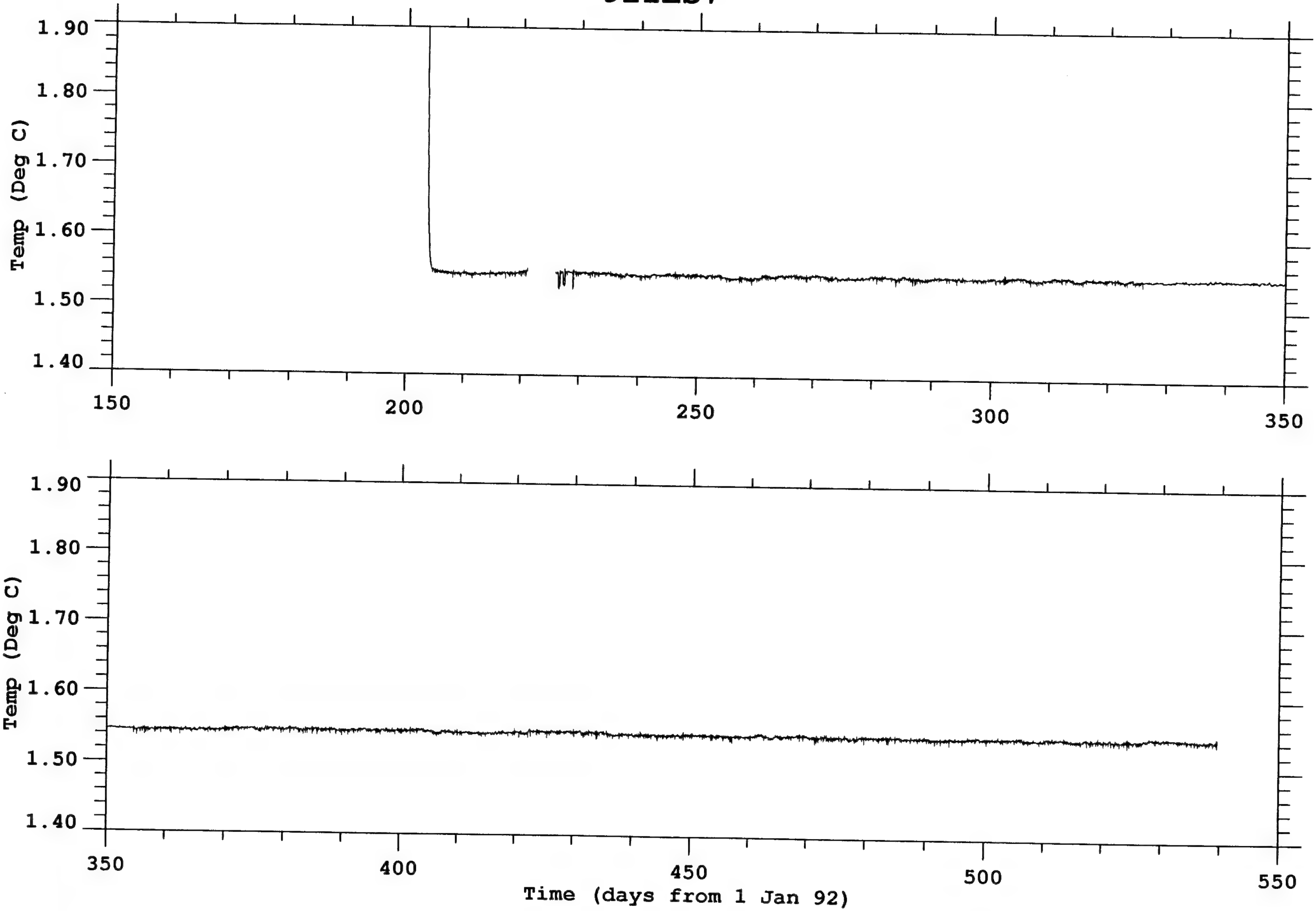
1.90
1.80
1.70
1.60
1.50
1.40
Temp (Deg C)
150
200
250
300
350
1.90
1.80
1.70
1.60
1.50
1.40
Temp (Deg C)
350
400
450
500
550
Time (days from 1 Jan 92)

92IES6



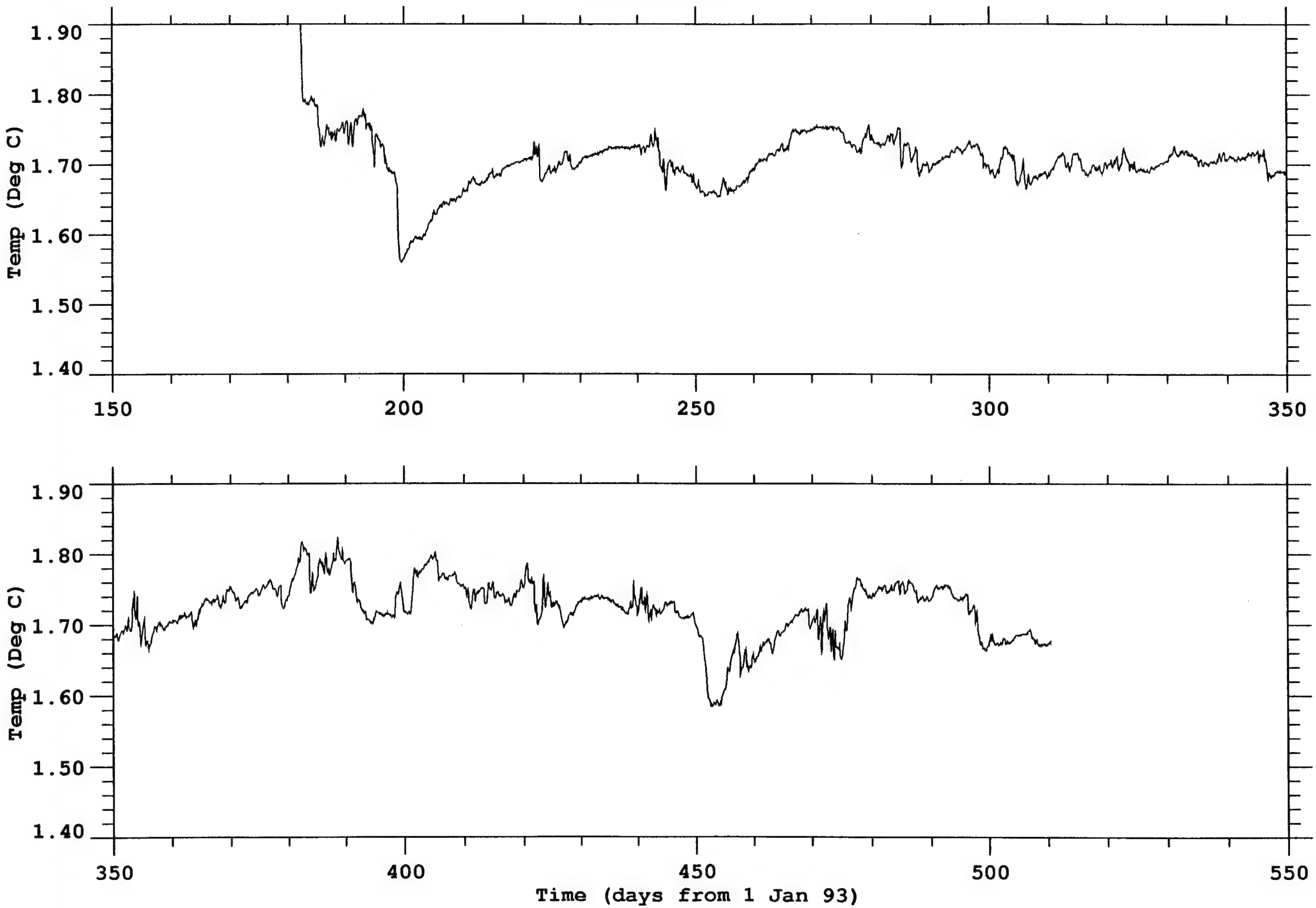
1.90
1.80
1.70
1.60
1.50
1.40
Temp (Deg C)
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

92IES7



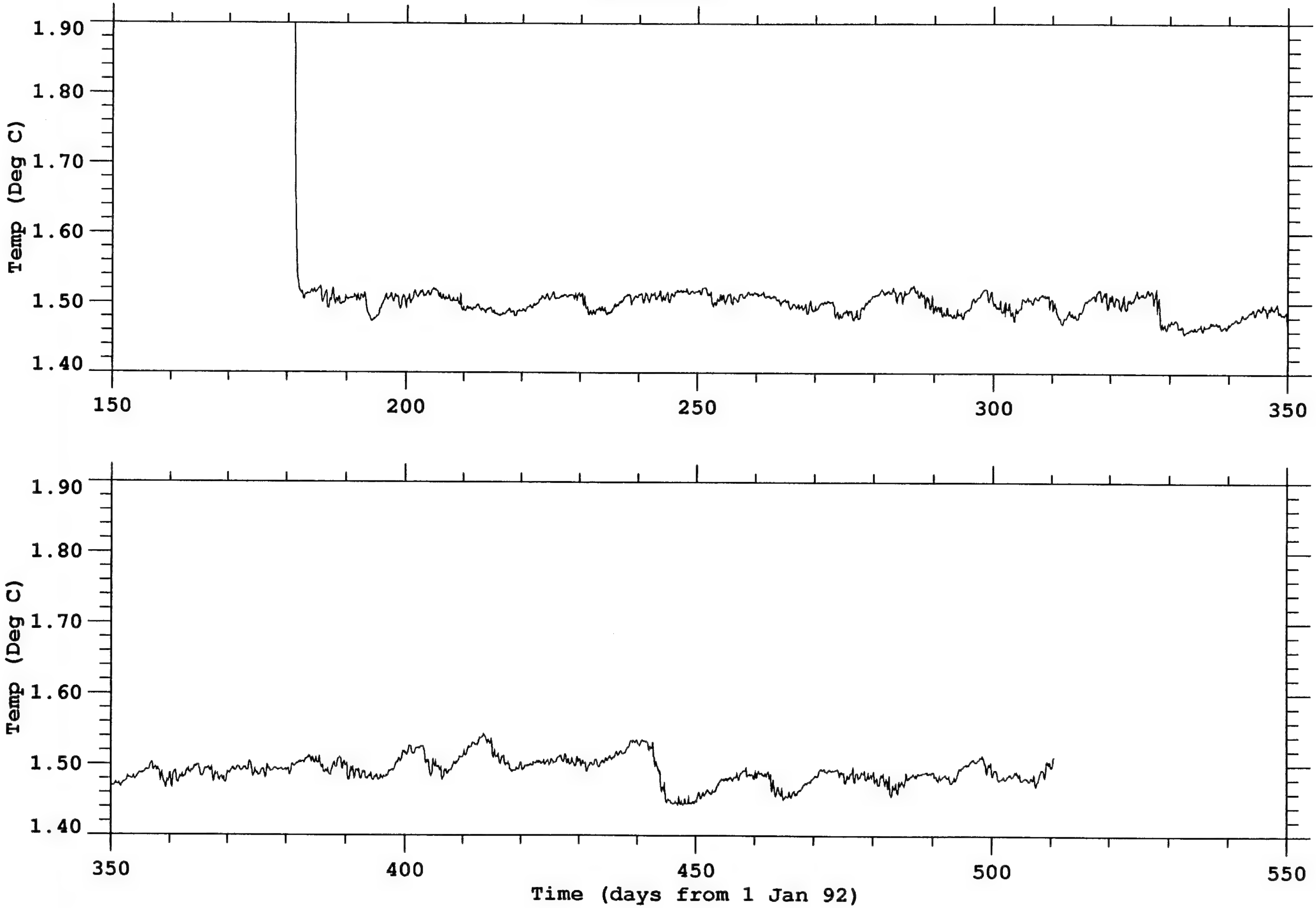
Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
150
200
250
300
350
Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
350
400
450
500
550
Time (days from 1 Jan 92)

93IES1



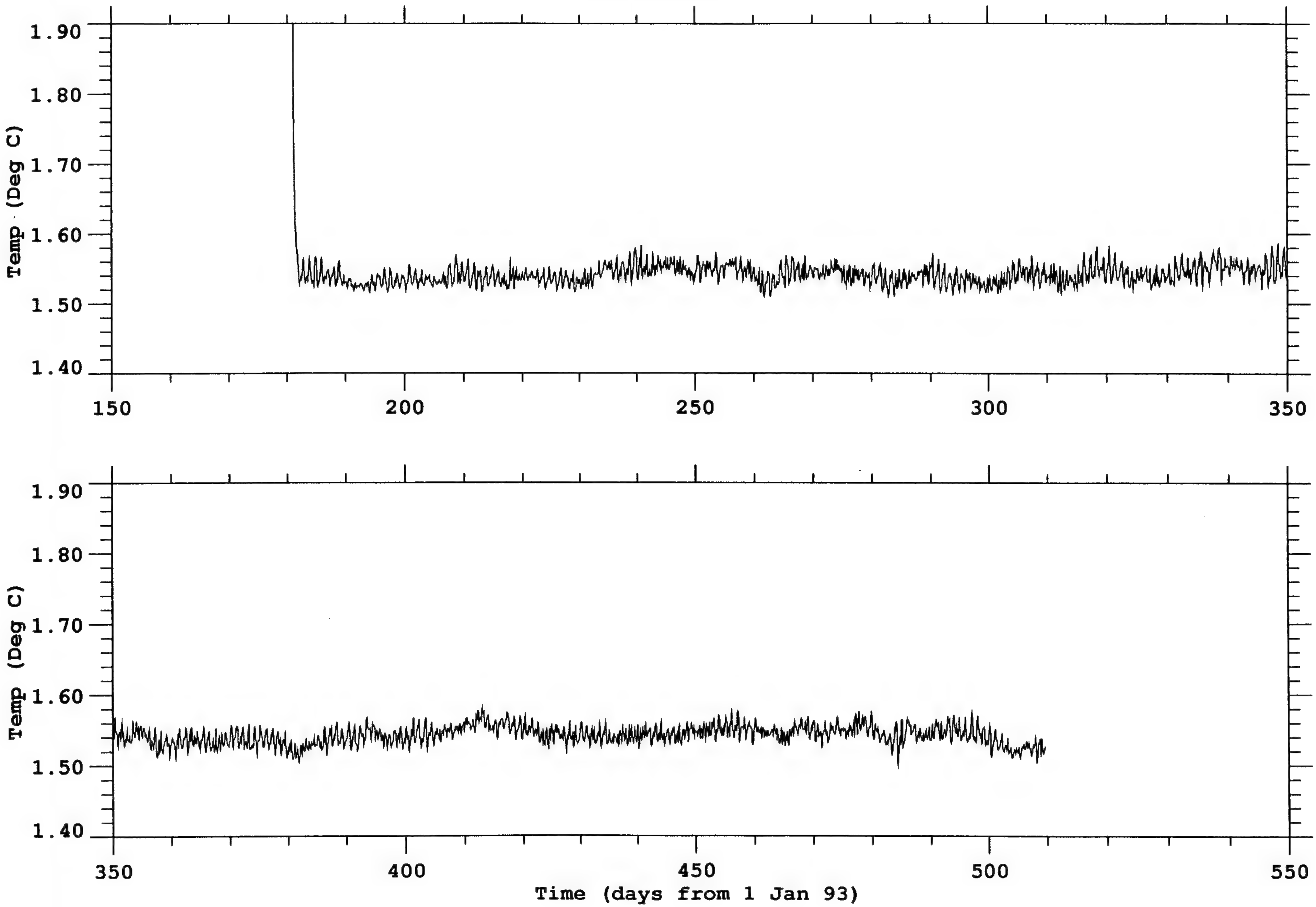
1.90
1.80
1.70
1.60
1.50
1.40
Temp (Deg C)
150
200
250
300
350
1.90
1.80
1.70
1.60
1.50
1.40
Temp (Deg C)
350
400
450
500
550
Time (days from 1 Jan 93)

93IES2



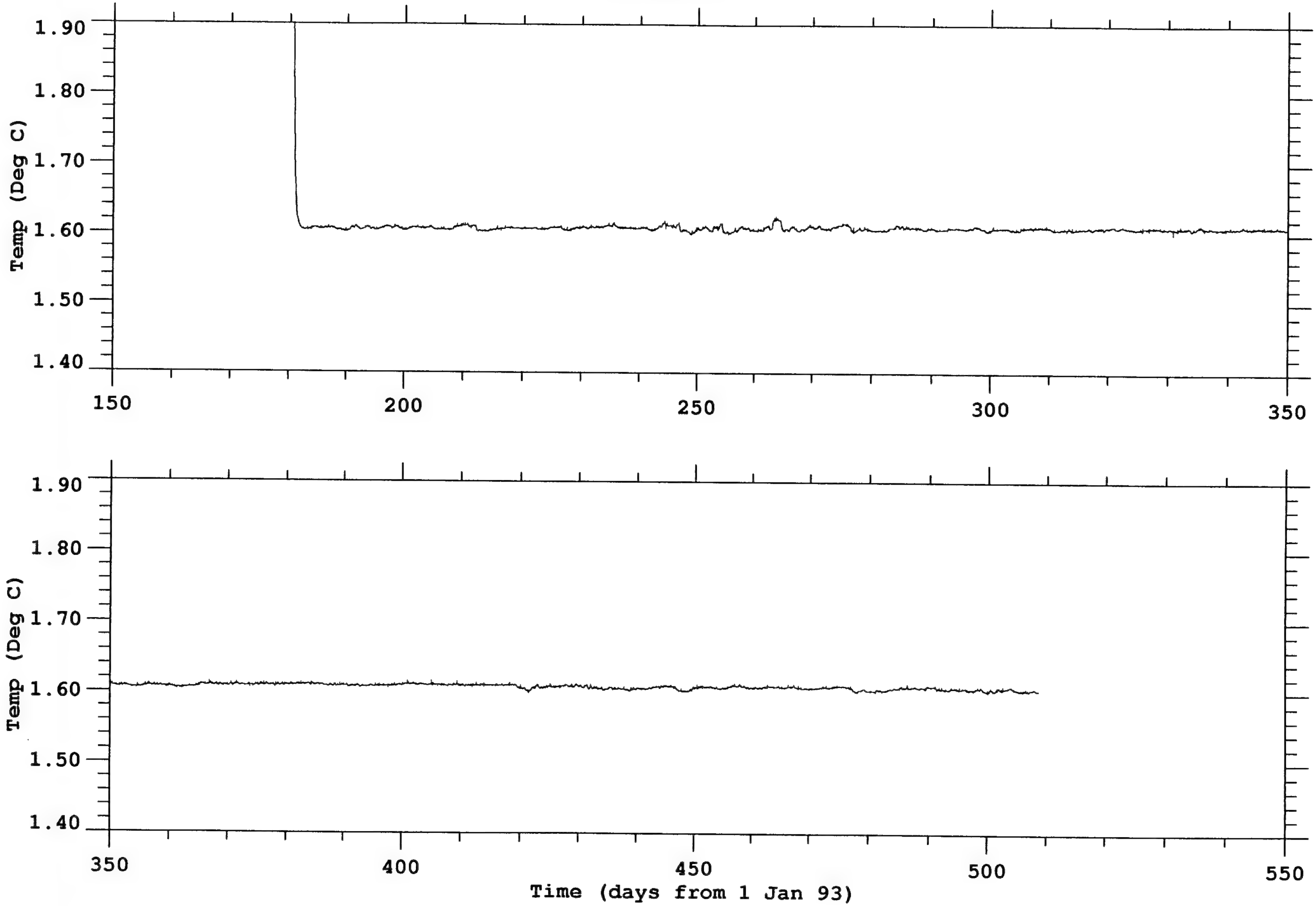
Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
150
200
250
300
350
Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
350
400
450
500
550
Time (days from 1 Jan 92)

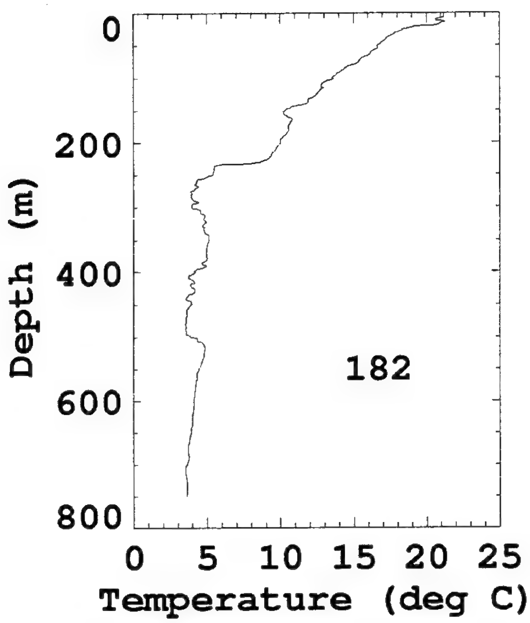
93IES3

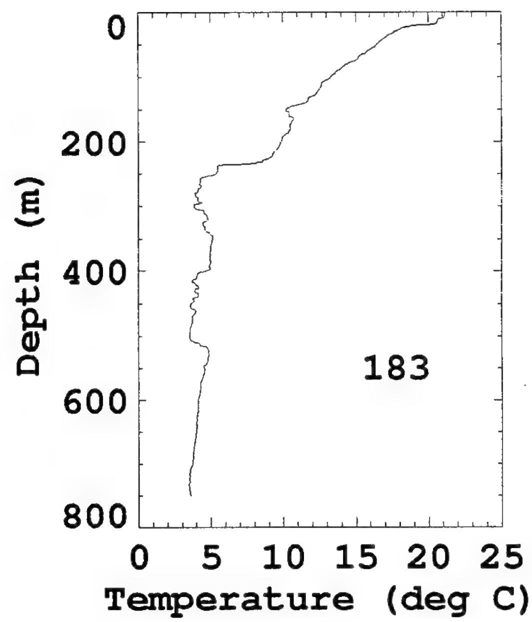


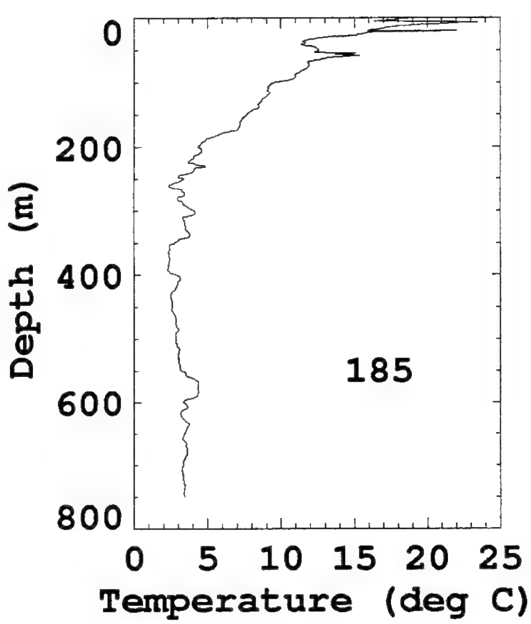
Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
150
200
250
300
350
Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
350
400
450
500
550
Time (days from 1 Jan 93)

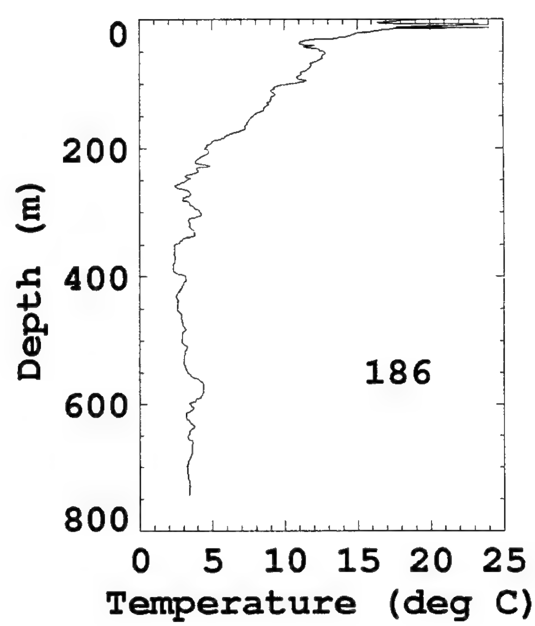
93IES5

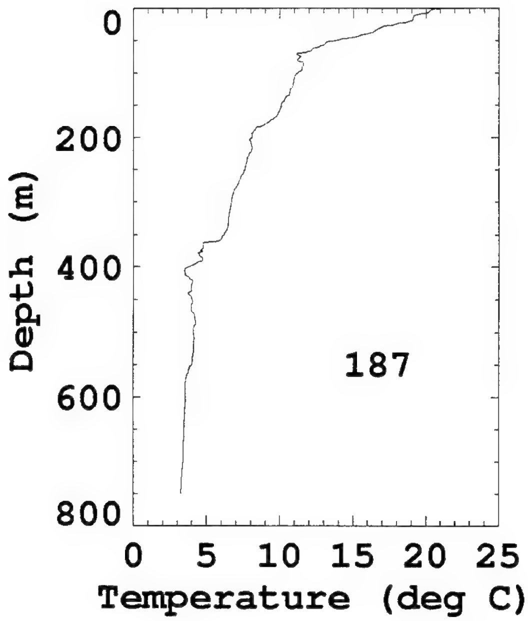

Temp (Deg C)
1.90
1.80
1.70
1.60
1.50
1.40
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

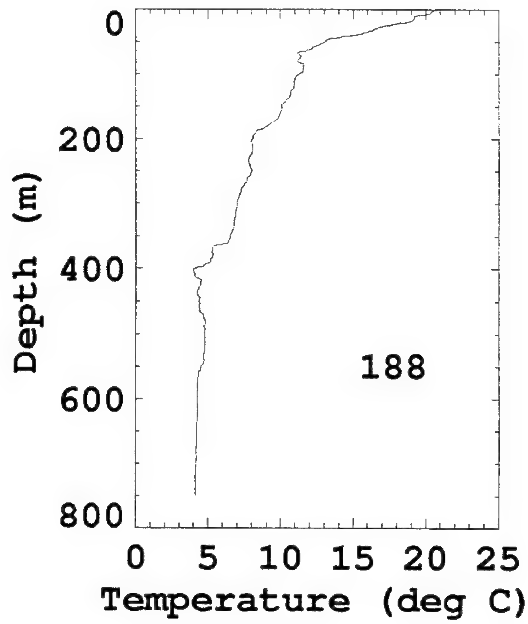

0
200
400
600
800
Depth (m)
182
0 5 10 15 20 25
Temperature (deg C)

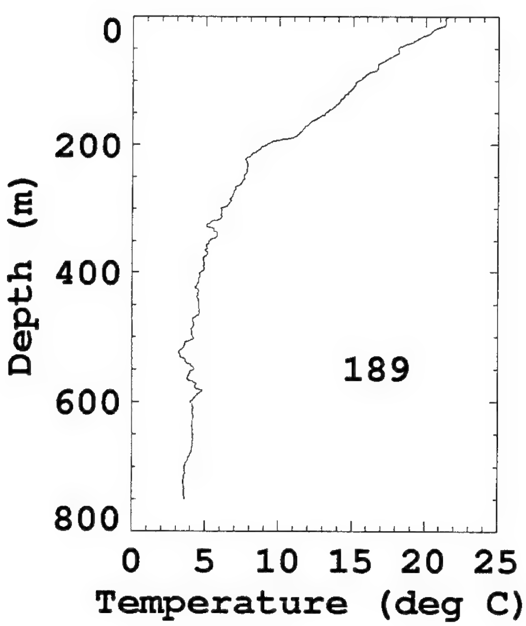

0
200
400
600
800
Depth (m)
183
0 5 10 15 20 25
Temperature (deg C)

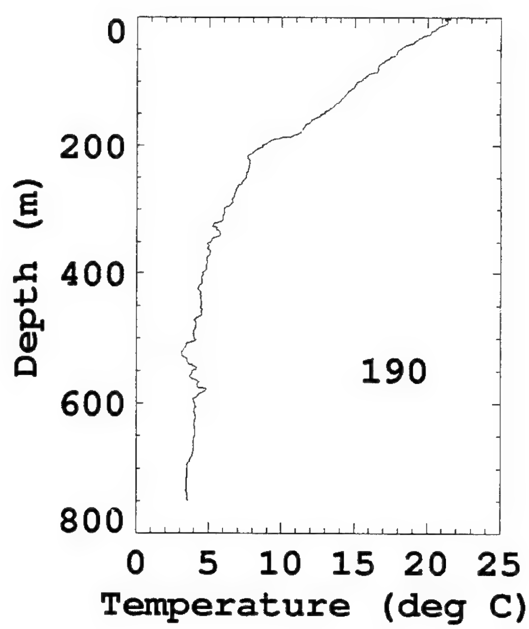

0
200
400
600
800
Depth (m)
185
0 5 10 15 20 25
Temperature (deg C)

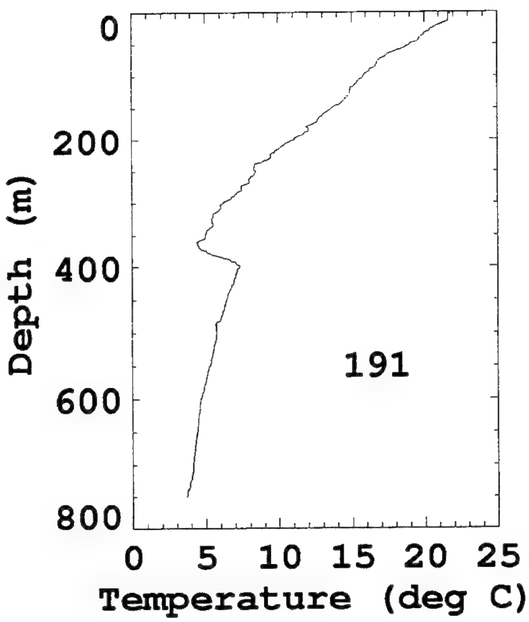

0
200
400
600
800
Depth (m)
186
0 5 10 15 20 25
Temperature (deg C)

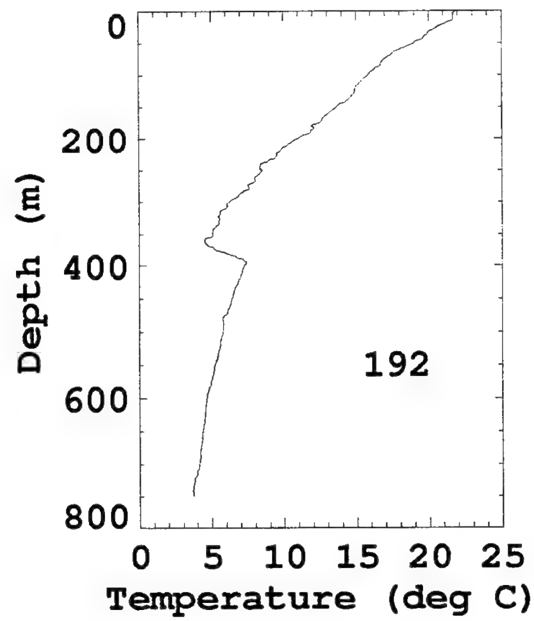

Depth (m)
0
200
400
600
800
0 5 10 15 20 25
Temperature (deg C)
187

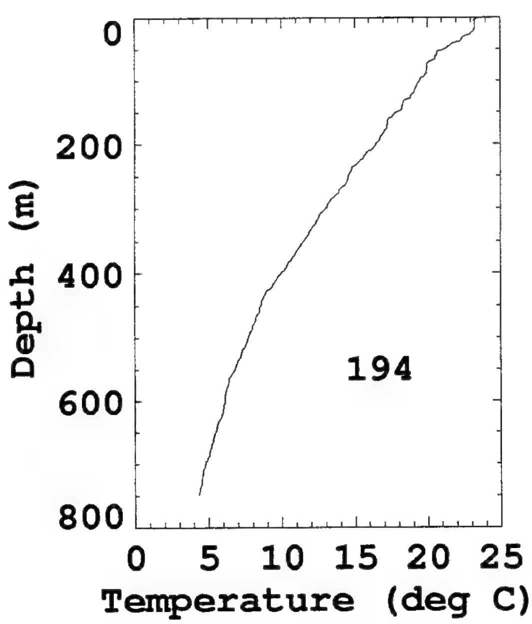

Depth (m)
0
200
400
600
800
0 5 10 15 20 25
Temperature (deg C)
188

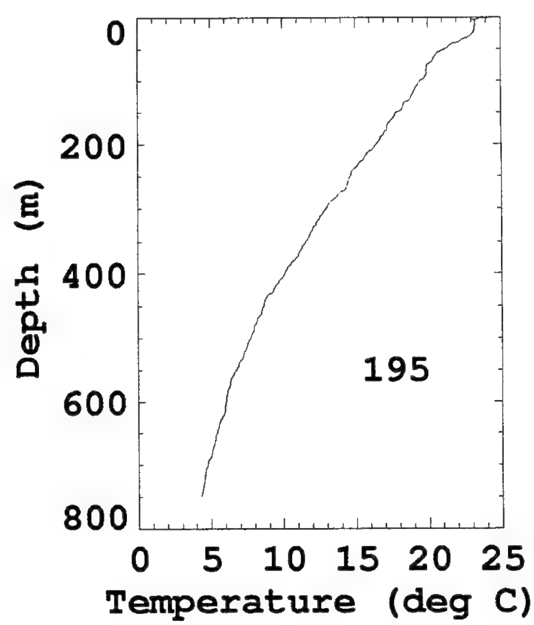

Depth (m)
0
200
400
600
800
0 5 10 15 20 25
Temperature (deg C)
189


Depth (m)
0
200
400
600
800
0 5 10 15 20 25
Temperature (deg C)
190


0
200
400
600
800
Depth (m)
191
0 5 10 15 20 25
Temperature (deg C)


0
200
400
600
800
Depth (m)
192
0 5 10 15 20 25
Temperature (deg C)


0
200
400
600
800
Depth (m)
194
0 5 10 15 20 25
Temperature (deg C)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Depth (m)
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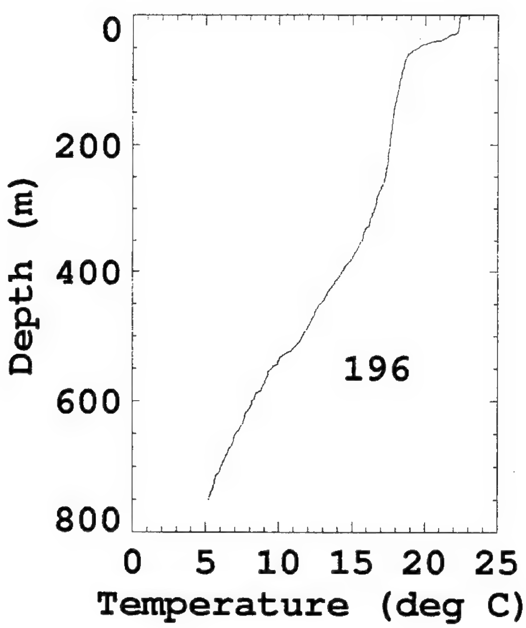
Temperature (deg C)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Depth (m)
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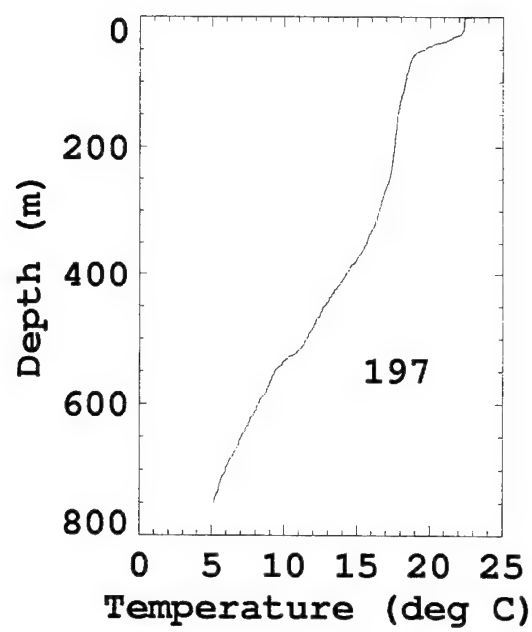
Temperature (deg C)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Depth (m)
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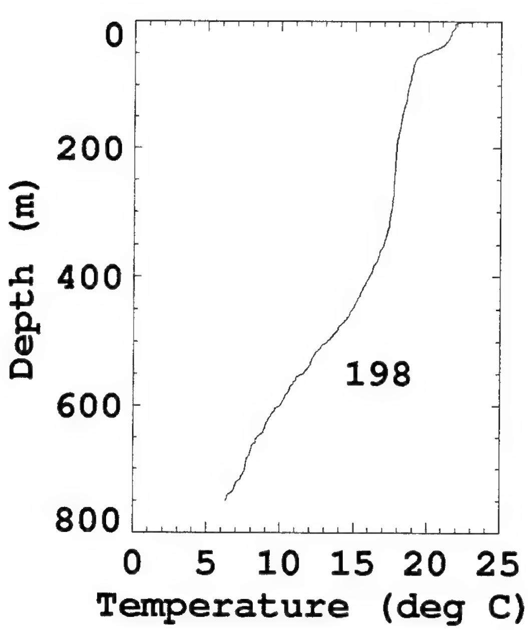
Temperature (deg C)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Depth (m)
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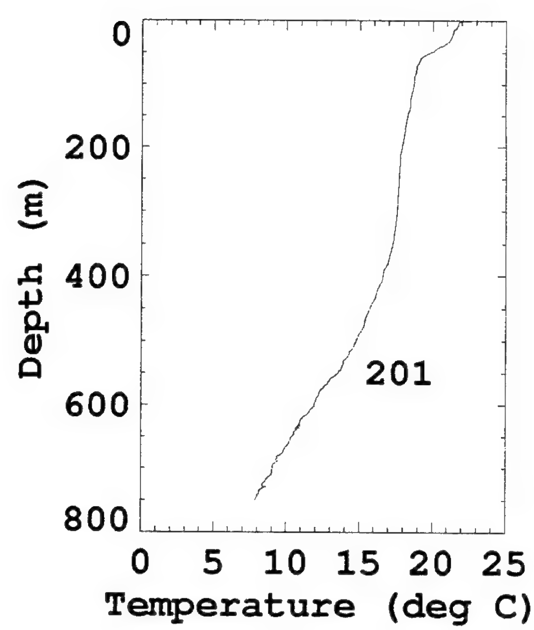
Temperature (deg C)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200
400
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800
Depth (m)
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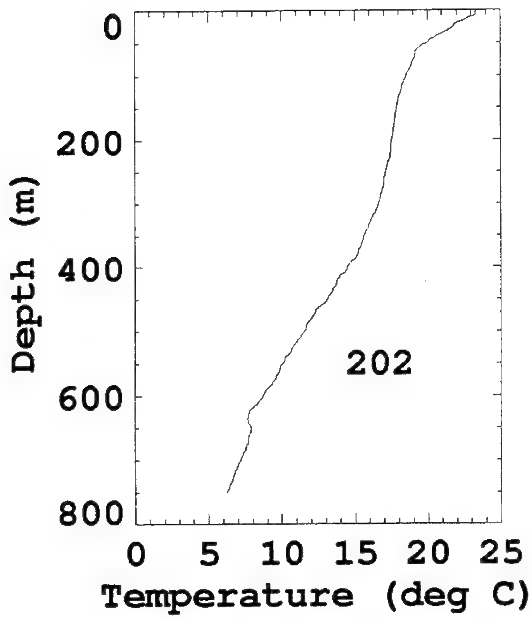
Temperature (deg C)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Depth (m)
Temperature (deg C)
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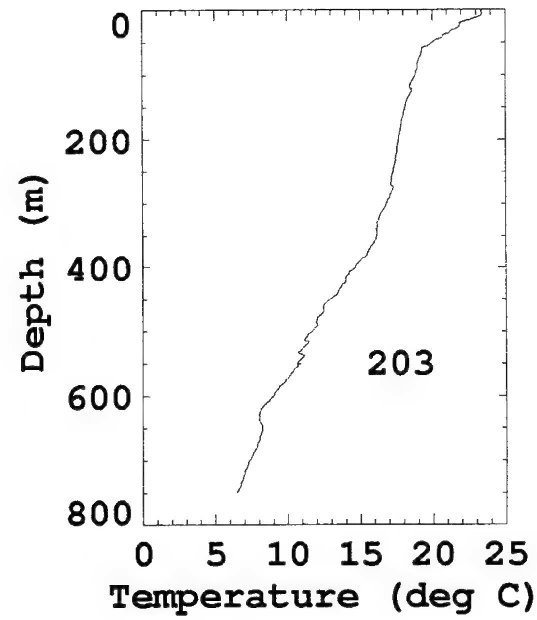
200
400
600
800
0 5 10 15 20 25


203
Depth (m)
Temperature (deg C)
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200
400
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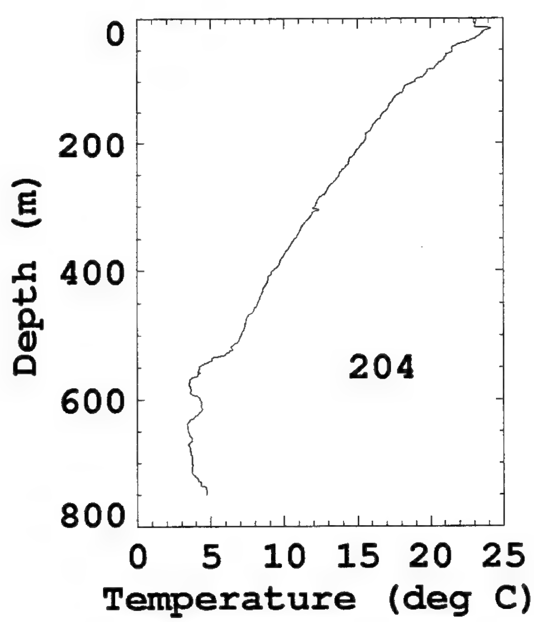
800
0 5 10 15 20 25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Depth (m)
Temperature (deg C)
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200
400
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800
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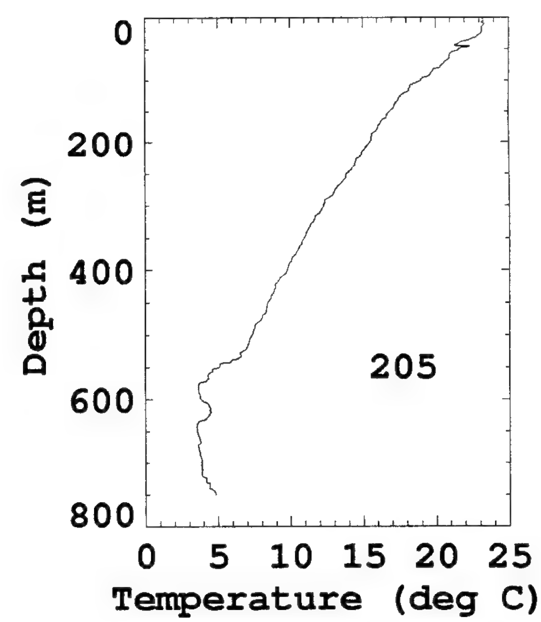
205
Depth (m)
Temperature (deg C)
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800
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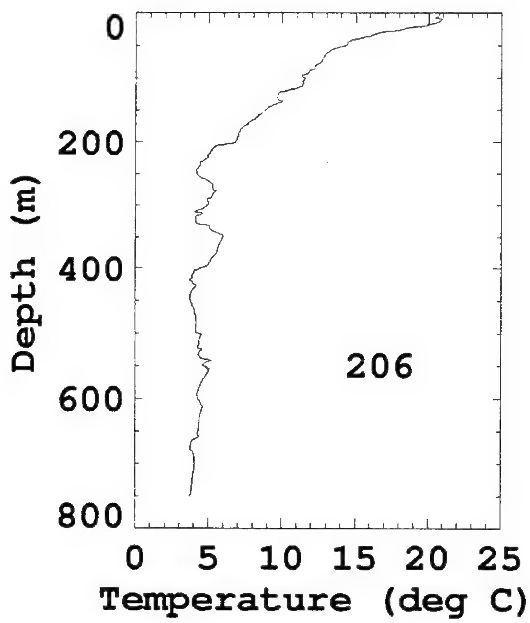
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Depth (m)
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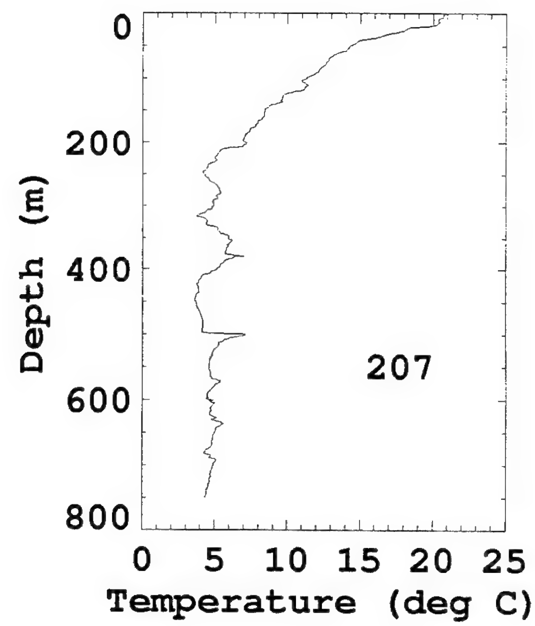
Temperature (deg C)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Depth (m)
207
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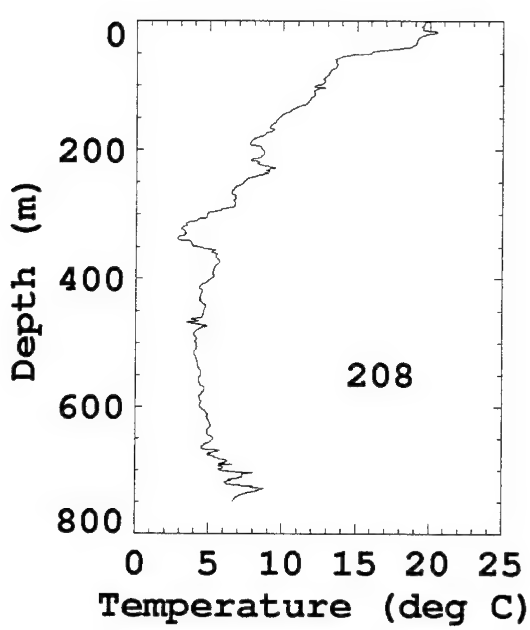
Temperature (deg C)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Depth (m)
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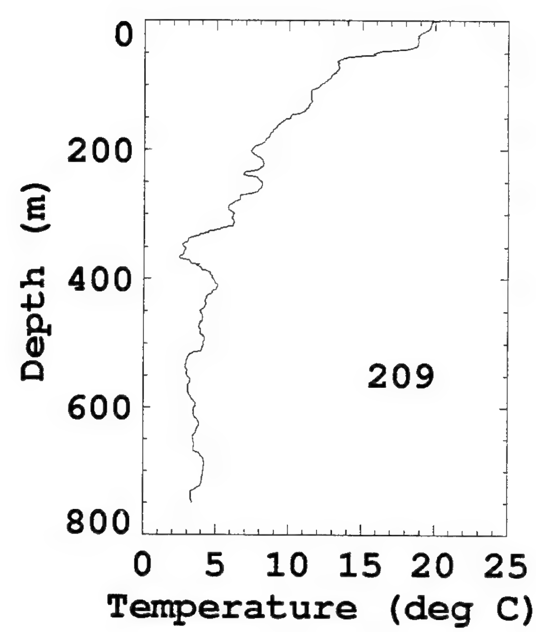
Temperature (deg C)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Depth (m)
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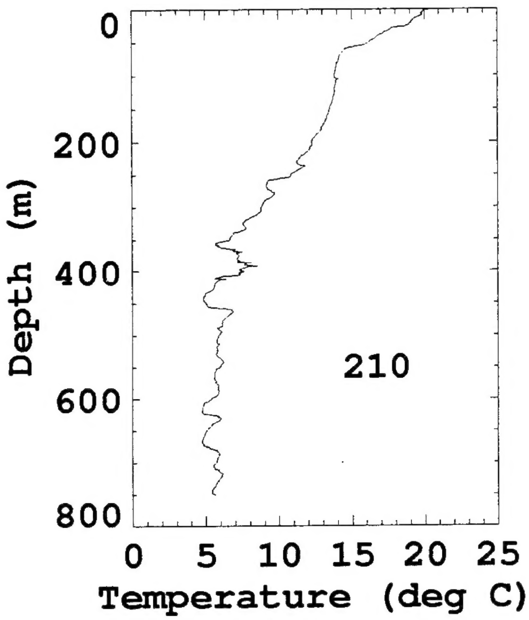
Temperature (deg C)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Depth (m)
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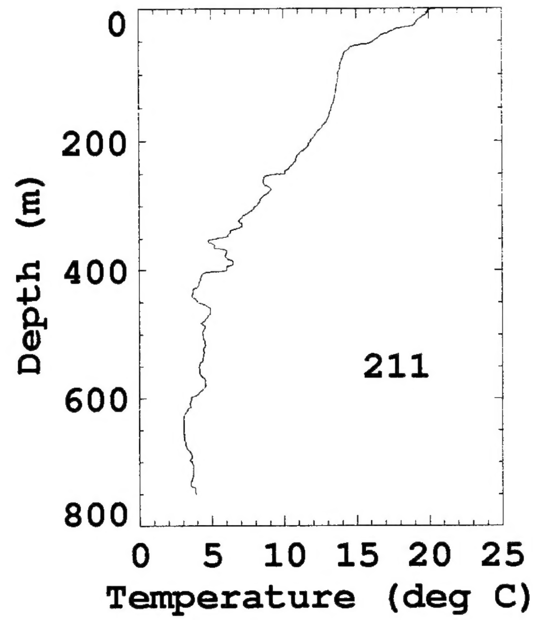
0 5 10 15 20 25
Temperature (deg C)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800
Depth (m)
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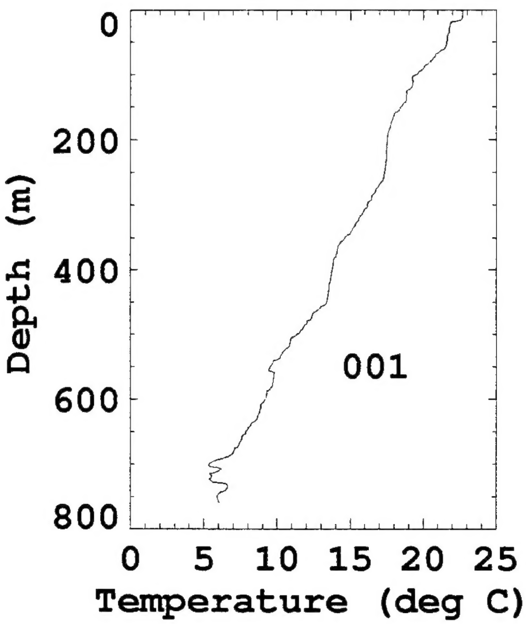
Temperature (deg C)



Depth (m)
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800
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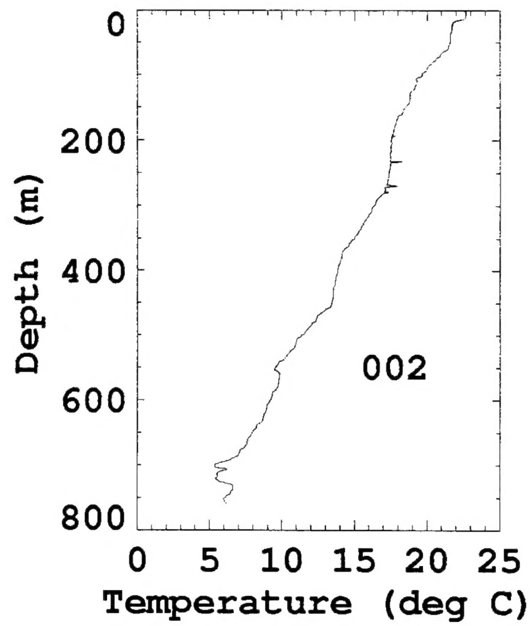
Temperature (deg C)



Depth (m)
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800
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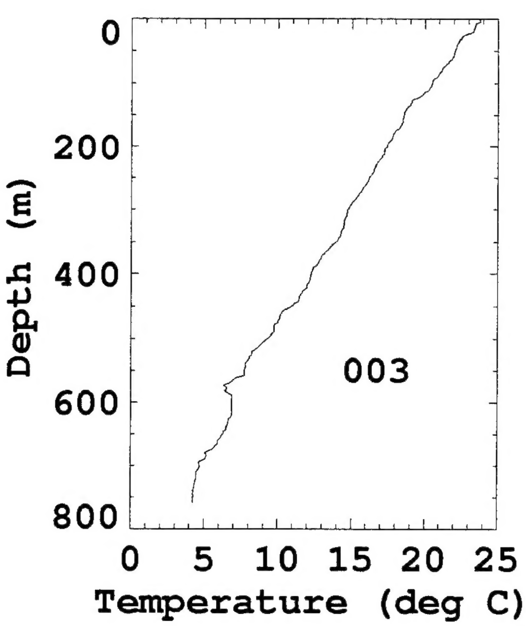
0 5 10 15 20 25
Temperature (deg C)



Depth (m)
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800
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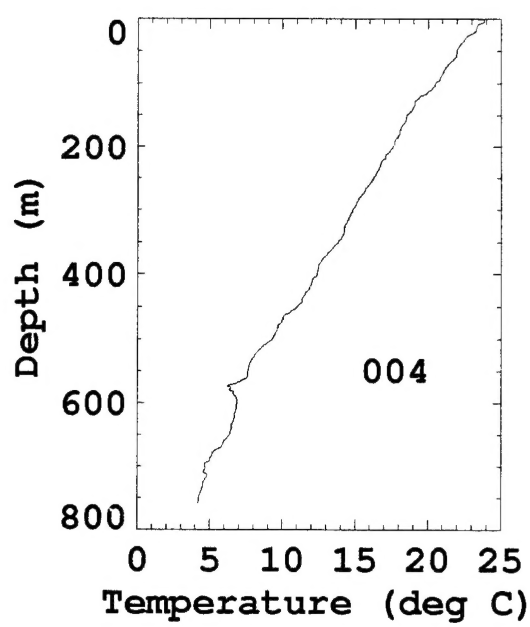
Temperature (deg C)



Depth (m)
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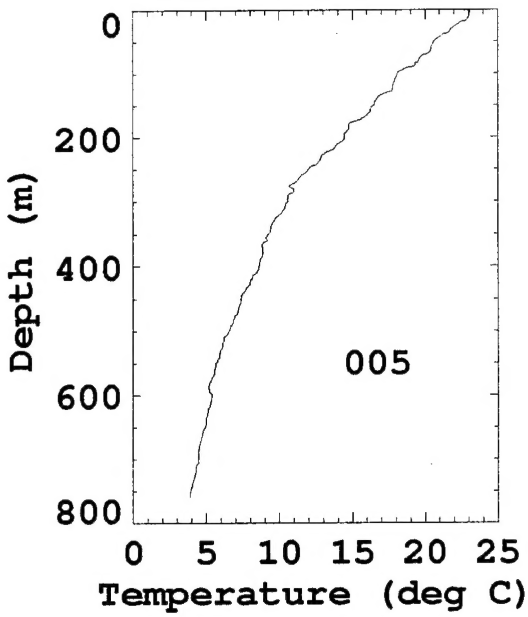
Temperature (deg C)



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Depth (m)
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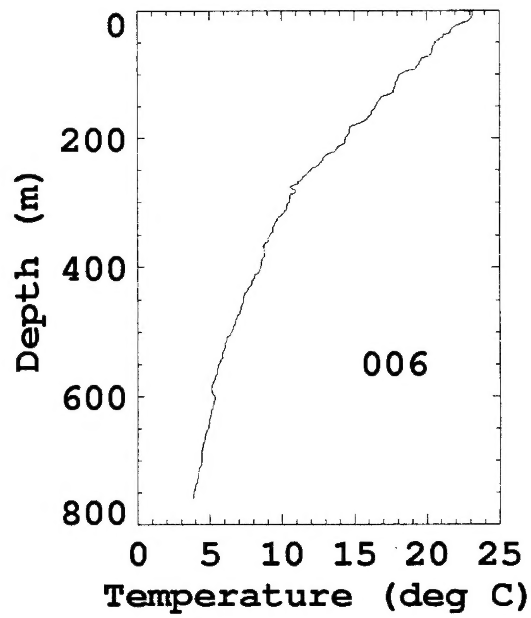
0 5 10 15 20 25
Temperature (deg C)



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Depth (m)
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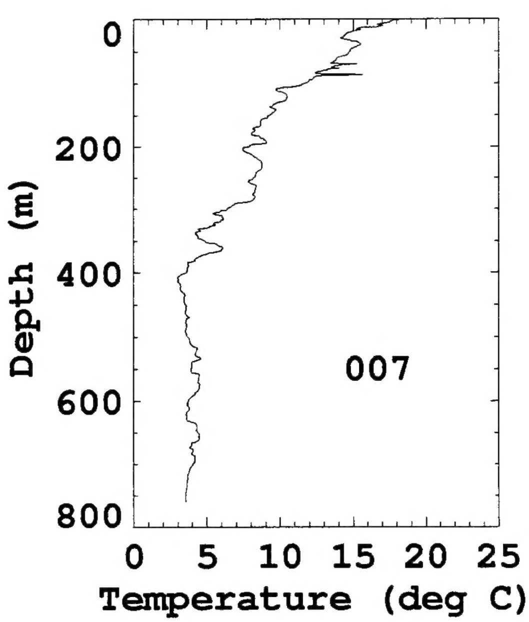
Temperature (deg C)



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400
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800
Depth (m)
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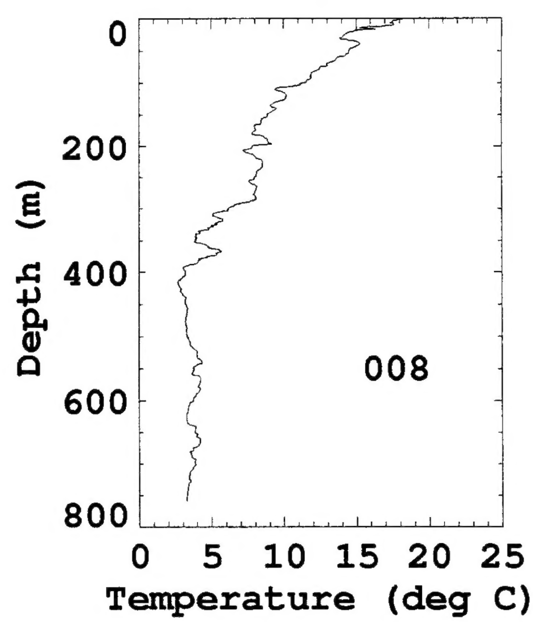
0 5 10 15 20 25
Temperature (deg C)



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Depth (m)
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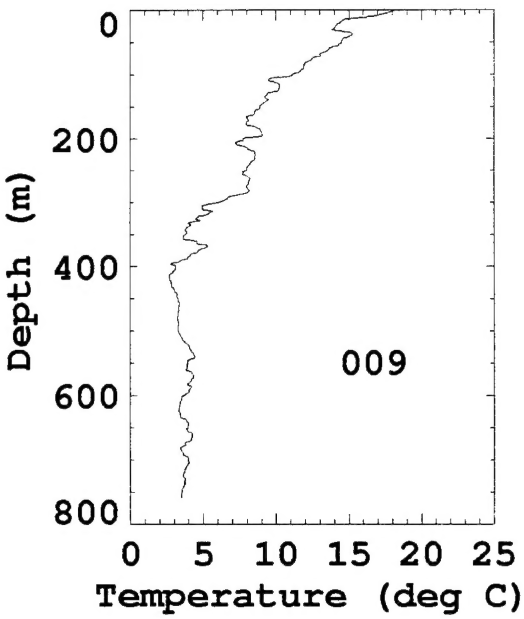
0 5 10 15 20 25
Temperature (deg C)



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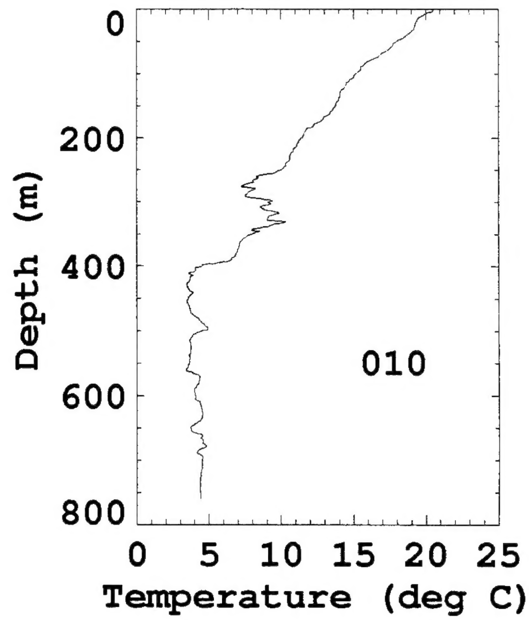
800
Depth (m)
009
0 5 10 15 20 25
Temperature (deg C)



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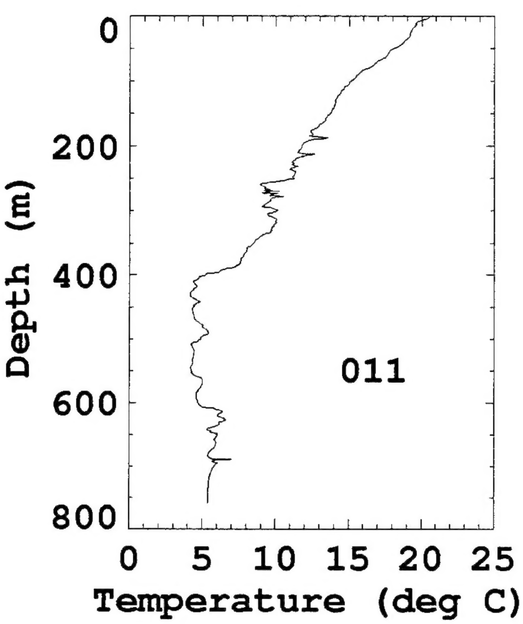
Depth (m)
010
0 5 10 15 20 25
Temperature (deg C)



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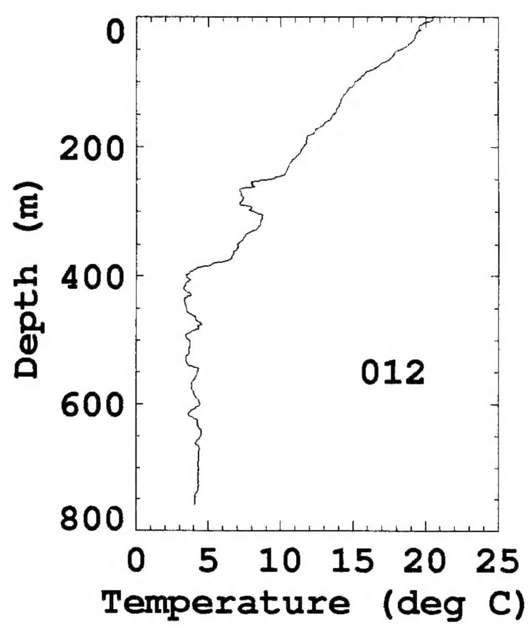
Depth (m)
011
0 5 10 15 20 25
Temperature (deg C)



0
200
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Depth (m)
012
0 5 10 15 20 25
Temperature (deg C)